OCTOBER 1956

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

FIVE DOLLARS A YEAR

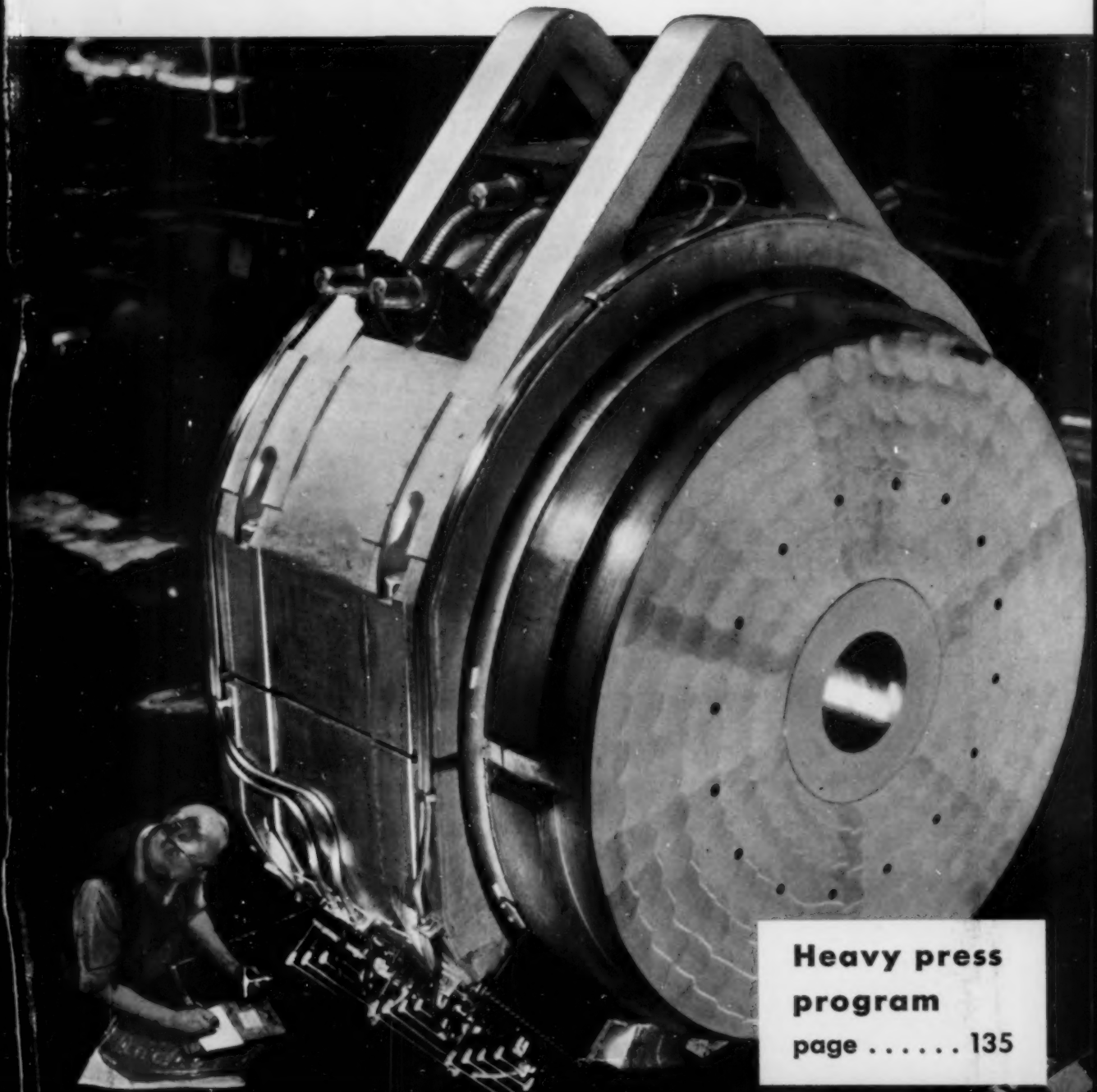
Why Bearings Fail

Common causes, remedies

Homologous Temperatures

Specifying Fhp Motors

Flow Through Orifices



Heavy press program
page 135

C/R cooperative research

helps you solve sealing problems BETTER, FASTER

These unequalled facilities are at your service

TESTING

Four complete C/R test laboratories are maintained solely to verify seal designs and materials with your specifications, with test runs in special C/R Machines and in customer units.

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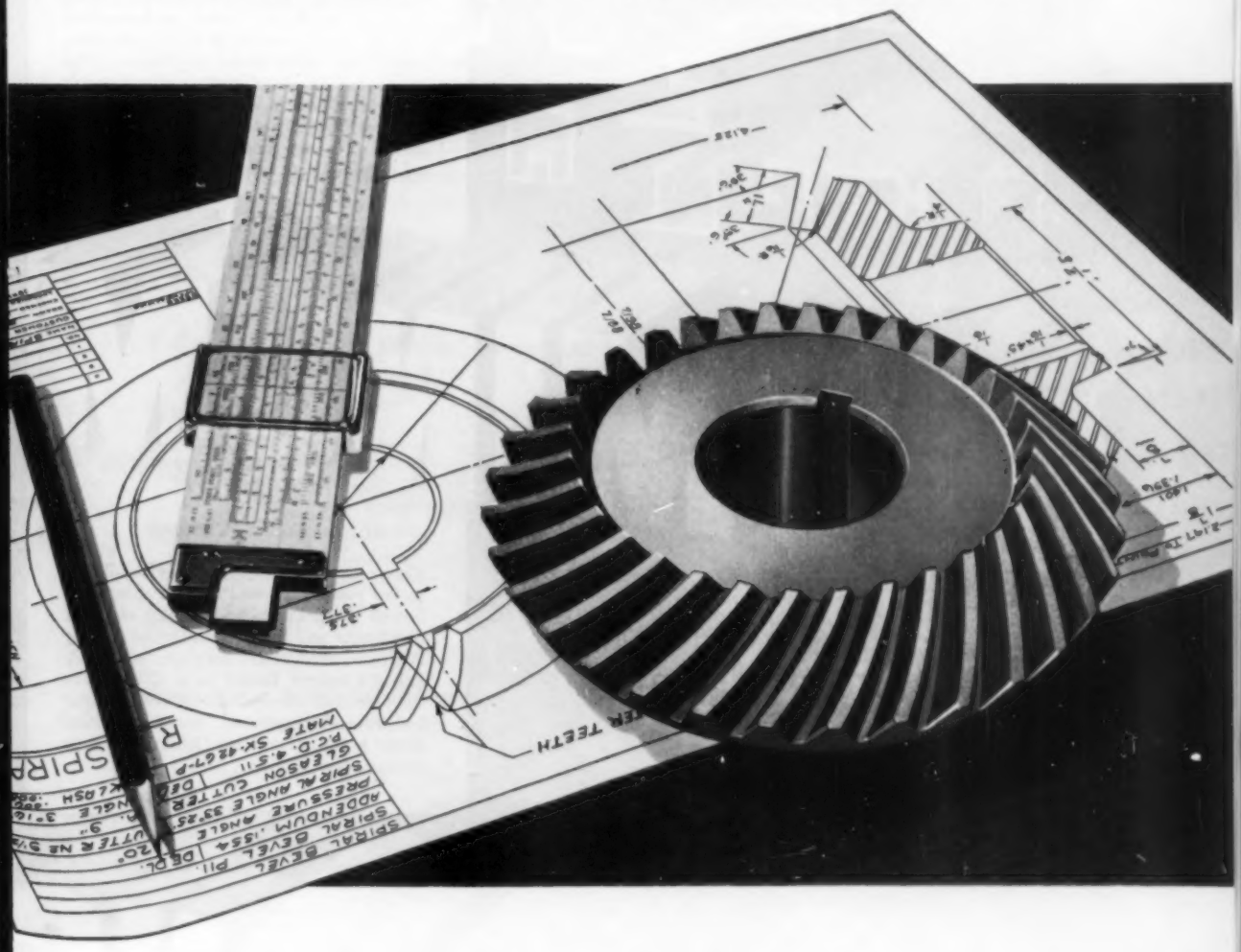
C/R CHICAGO RAWHIDE

"ENGINEERED QUOTATIONS"

When our engineers study our customers' prints, they look for ways to improve gear performance, ways to simplify gear installations, ways to cut gear costs. When they find a way that they consider better they report it to the customer for his consideration. Very often these "engineered quotations" are accepted. Such careful scrutiny of every engineering and manufacturing step by *gear specialists* is one reason why so many manufacturers use Automotive Gear Works as their "gear department". May we submit an "engineered quotation" on your gear requirements?



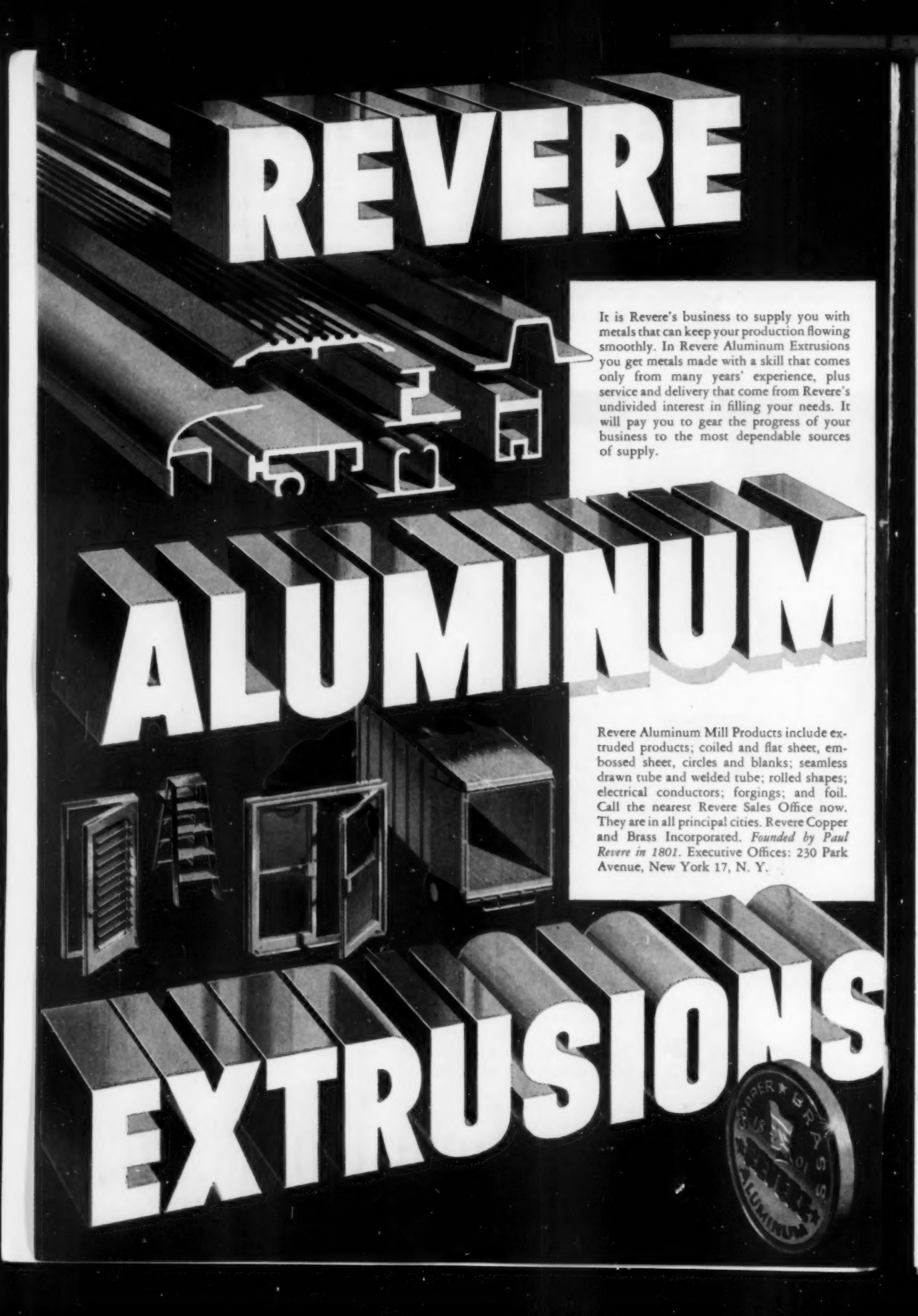
DOUBLE DIAMOND GEARS

FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Automotive Gear Works, inc.

ESTABLISHED IN 1914 — RICHMOND, INDIANA

SUBSIDIARY OF EATON MANUFACTURING COMPANY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Product Engineering

OCTOBER 1956 Vol. 27 No. 10 The McGraw-Hill Magazine of Design Engineering

A Review of the Heavy Press Program ..... John Alico 135
Why the program was initiated and presses now in operation; some of the early problems in design and transportation of parts; need for still larger presses.

Nomograph for Designing Gas Nozzles and Orifices ..... Eugene Gessner 141
Gives weight of flow if pressure ratio, upstream pressure and diameters are known.

Design Features in New Products 144
Electro-hydraulic press control; squeeze riveting an assembly; liquid air machine; die-cast bandsaw frame; cams sequence pump motions; photo-cell resets camera; mass flowmeter spring-stabilized; timing hydraulic cylinders; plane fueling cart.

Simple Suggestions Concerning Shortage of Engineers ..... Alfred M. Cooper 158
The shortage is now chronic, yet there are some simple things any company can do.

Metals At Elevated Temperatures ..... R. W. Guard 160
Hot and cold behavior compared using homologous temperature scale; fatigue vs rupture stress as criterion; predicting long-term properties from short-term tests.

Collapsing Pressures of Non-Symmetrical Bodies ..... Melvin Mark 165
Equations for determining strength of hollow non-symmetrical bodies.

Why Bearings Fail ..... D. F. Wilcock and E. R. Booser 167
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Use of Mock-Ups in Design ..... George W. Michalec 183
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Applying Single-Phase, Capacitor-Start Motors ..... J. D. Aubry 196
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Aluminum and Magnesium Extrusions ..... J. J. DePaolo 200
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Nomograph can be used to convert entire units from one system to another.

Force-Speed-Horsepower Nomograph ..... Leo Fiderer 219
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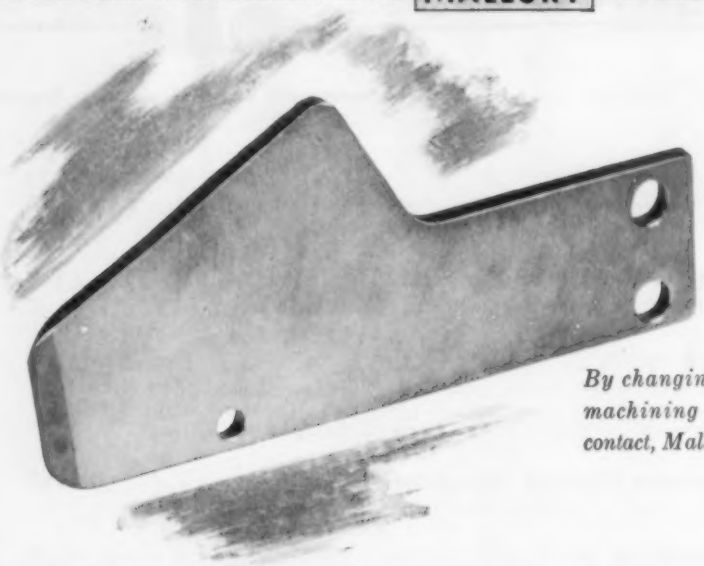
MALLORY



By changing materials, simplifying machining on this voltage regulator contact, Mallory engineers cut costs 25%.

Value Analysis by Mallory Saves Money on Contacts

Mallory Contact Engineering Offers Five Ways To Improve Economy

1. **The most effective contact material** from the extensive line developed by Mallory. More economical alloys often can satisfy *actual* service conditions.
2. **The most economical contact design . . .** for your purchasing, production and product needs.
3. **The most economical backing material** . . . from a group of Mallory alloys developed for this use.
4. **The most economical backing member design** in relation to contact and product design requirements.
5. **The most economical method of assembly** of contact and backing member.

By coordinating *all* these important elements of contact design, Mallory can help you put into effect a long-range plan for cutting contact cost and assuring peak performance.

BETTER not take electrical contacts for granted. There's much more to contact design than meets the eye. Often Mallory engineers can, through a detailed analysis of requirements, recommend changes that amount to real savings.

The contact shown here, for a substation transformer voltage regulator, illustrates how deeply Mallory engineering penetrates into contact design. First step after scrutinizing all aspects of the application, was to change the material to Mallory ELKALOY® A. *This change gave a more economical alloy to work with . . . at no sacrifice of performance for the intended use.* Then, Mallory specialists recommended simplifications in manufacturing. Instead of a double disc finishing operation, they used a rolled-finish product . . . with less waste, less cost. Also eliminated as unnecessary to the desired service were three complete operations: sanding of the entire edge of the piece, and counterboring of holes for hold-down bolts and buffing of the chamfered end.

The contact is now being manufactured under simplified specifications, free of unnecessary "frills"—and gives equal performance *at 25% less cost!*

This is the kind of thorough, cost-conscious engineering that Mallory can apply to your own electrical contact designs. Our extensive experience in contact alloys, contact design and contact assembly engineering is ready to serve you. Write or call Mallory for a consultation.

Expect more . . . get more from

Serving Industry with These Products:

Electromechanical—Resistors • Switches • Tuning Devices • Vibrators
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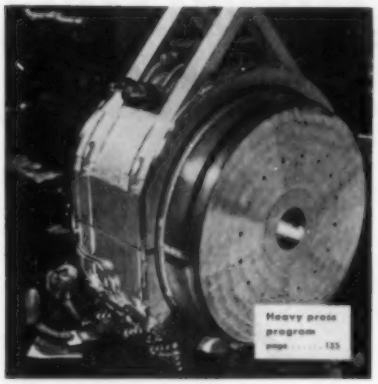

THIS MONTH'S COVER

Latest installation in the Air Force Heavy Press program to go into production is at Hale-thorpe, Md. Billet containers for these 8000-ton extrusion presses were built by Bethlehem Steel for Lowey-Hydropress. For the current status of this Heavy Press program, see the article starting on page 135.

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Developments

To Watch

CEMENT IN COILS . . . .

. . . . is a new concept in the handling and application of cements. Called Thermogrip and developed by the B. B. Chemical Co., Div. of United Shoe Machinery Corp., the cements are dry and completely solid thermoplastic adhesives that are fed in the form of a cord from a spool into an applicator that melts, feeds, and applies it. Only a small amount of the cement is subjected to heat and is in molten form at one time. The chief advantages are: no mixing, weighing, and handling of liquids; the cement is ready to use when received and is placed on a holder and fed into the applicator; only a small heating unit is necessary; and there is no change in the cement composition caused by evaporation or settling. The Thermogrip applicators can be designed for existing machines, or as special units in new machinery. The cements will bond wet strength Kraft and other papers, chip board, polyethylene films and polyethlene coated paper and board, wax coated paper and board, aluminum foil, fabrics, and others. For further information contact the Industrial Sales Div., United Shoe Machinery Corp., 140 Federal St., Boston, Mass.

STAINLESS STEEL THREADS CAST IN CAST IRON . . .

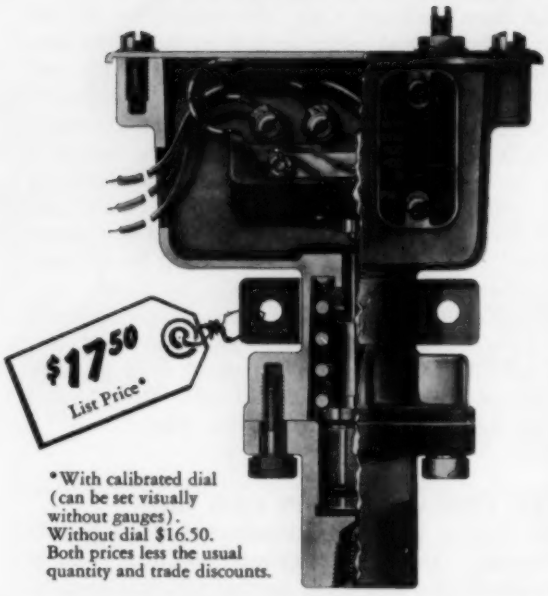
. . . . have cut material handling costs and eliminated expensive drilling and tapping on large parts, according to the E. L. LeBaron Foundry Co., Brockton, Mass. The method was developed by LeBaron, and incorporates the stainless steel wire inserts made by Heli-Coil Corp., Danbury, Conn. The inserts are placed in the mold on sand cores. The hot metal flows around the outside of the inserts forming a bond just short of actual fusion. The cores inside the inserts are removed by standard blast cleaning equipment.

WITH A HEAT ABSORPTION RATING OF 96.5 PER CENT . . . .

. . . . the highest of any finish tested, a mica-pigmented coating based on Dow Corning silicone resins has been developed by that company in Midland, Michigan, for use on electrical appliances. Almost colorless, the finish is thin and flexible enough to withstand heat expansion and contraction inside an appliance, yet retain its physical and absorptive values despite long exposure to temperatures of 500 F. In a waffle baker, it reduced the power required from 1000 to 800 watts, and halved the preheat and cooking time. Much of the difference in performance was obtained by coating the underside of the aluminum grids with a heat absorbing cement. The improvement caused the thermostat in the baker to lag and overtravel. The thermostat itself was then coated with the silicone-mica finish, and a baffle coated with the finish was installed to cut off radiation from the coils. Table-top temperature also was reduced from 186 to 120 F.

(*Continued on page 7*)

If you build PRODUCTION EQUIPMENT compare this pressure switch for RUGGEDNESS, DEPENDABILITY and COST



*With calibrated dial (can be set visually without gauges). Without dial $16.50. Both prices less the usual quantity and trade discounts.

WE BUILD IN	WE DON'T USE
RUGGEDNESS Can take surges— (High proof pressures) Continuous operation— (Millions of cycles) No sticking— (in dirty fluid)	**LINKAGES & BEARINGS** Which wear quickly—(cause settings to drift and switch to fail).
LABOR & MATERIAL SAVINGS No return drain piping— (Sealed piston) Mounts where convenient (Operates in any position, Not sensitive to vibration)	**UNSEALED PISTONS** Which add to your installation cost (return piping). Are critical to dirt— (pistons get stuck).

BARKSDALE VALVES

PRESSURE SWITCH DIVISION
5125 Alcoa Avenue, Los Angeles 58, California

Ask for bulletins 9612 and C9612.

ARE YOU CHANGING DESIGN ON AIR OPERATED MACHINES TO CUT COST AND IMPROVE OPERATION?

*$18.50 is the list price for the ¼ inch port size and $19.50 for the ⅜ inch, less the usual quantity and trade discounts.

HERE'S BOTH LOWER COST AND BETTER CONTROL IN THE 'SHEAR-SEAL 4-WAY AIR VALVE

You need no oiler and filter ahead of this valve because it's made entirely of corrosion resistant materials and moisture won't harm it.

It operates freely on dry, unlubricated air, and dirt or pipe scale in the line cannot damage the valve or hold it open because of the unique "Shear-Seal" design.

The leak-proof holding quality which does not diminish after prolonged service is perhaps the most outstanding characteristic of the wear-compensating "Shear-Seal."

The external design stresses savings through convenience of porting, any port can be the "in" port; of mounting, valve has a bracket that may be shifted or removed to make way for panel mounting; of maintenance, valve can be serviced without touching the plumbing.

Ask for bulletin A-5.

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

Developments to Watch

PLASTIC PARTS FROM IRRADIATED POLYETHYLENE . . . .

. . . . are being fabricated experimentally by General Electric's Chemical Dept., Pittsfield, Mass. Known as Vulkene 107-E vulcanized reinforced polyethylene, the new material is a carbon-black filled, tough, flexible plastic with physical properties, heat and chemical resistance reportedly superior to conventional high pressure polyethylene, from which it is derived. Yield strength at low temperature is said to be double that of polyethylene, and creep deformation is reduced to approximately 10 per cent of the value obtained for polyethylene. Reportedly it can be carried to its decomposition temperature without melting. At 300 F it retains a tensile strength of 500 psi. GE is presently test marketing a modification of the material as a semi-conductor tape in shielded powercable.

A HARD SURFACING AGGLOMERATED ALLOY FLUX . . . .

. . . . H-560, has been developed for use with the submerged arc welding process to produce a hardsurfacing deposit. Using a mild steel electrode, the flux will produce a high carbon, high alloy weld deposit with a hardness of 53 to 61 Rockwell "C." The deposits are said to resist scaling and flaking and can be used for the hardsurfacing of crushing rolls and rings, and extruder piston heads, etc. The flux will perform successfully under abrasive conditions at temperatures as high as 1100 F according to its developer Lincoln Electric Co., Cleveland, Ohio.

AN IMPROVEMENT OF CONTINUOUS CASTING . . . .

. . . .for steel and nonferrous alloys applies a gas plating process to coat cast metals. Developed at Commonwealth Engineering Co., Dayton, Ohio, the apparatus uses the heat of a hot metal to volatilize the plating compounds. The gaseous atmosphere is continuously changing keeping up the level of the plating compound, while speed of the operation is governed by a roll drive or an equivalent mechanism. The annealing of the plated metal, done at higher temperatures than gas plating, is accomplished by induction heating. By a similar process clad steel sheet can be produced with a protective metal coating about 0.0005 in.

A SPRAYED STEEL COATING . . . .

. . . .scheduled for use on aluminum cylinder walls, is reported to be an asset in the design of the all-aluminum engine. According to the Aluminum Company of America, working with the Metallizing Engineering Co., Inc., Westbury, N. Y., the technique requires only a very thin layer of pure molybdenum between the aluminum and steel to serve as a bonding material. There is no longer a need for a mechanical anchorage of the sprayed steel to the aluminum cylinder. The steel coating will not offset the expansion of aluminum.

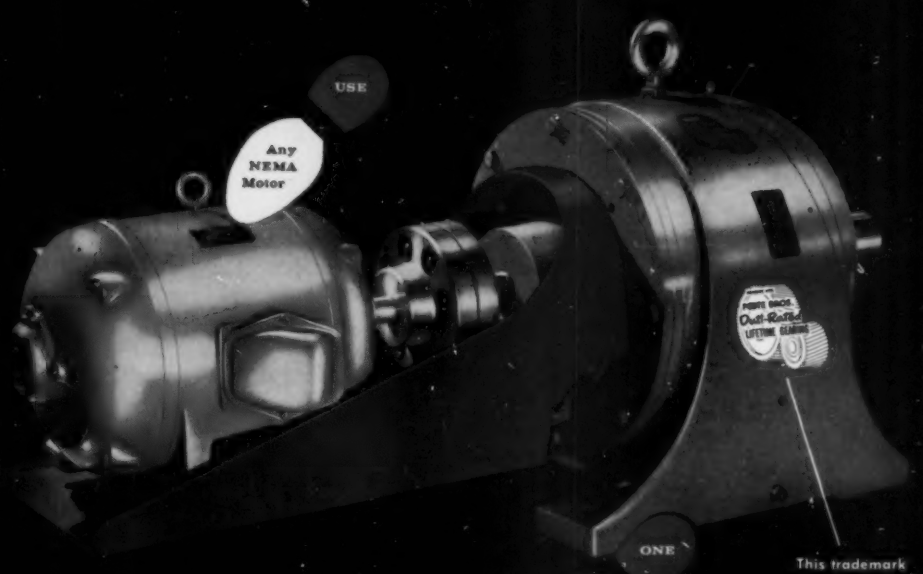
INDICATING A PREDETERMINED FREQUENCY OF MOTION . . . .

. . . . the main use of a new device is expected to be as an indicator of the predetermined rpm of an internal combustion engine. The atuned vibrator cartridge is similar to those used in d-c power supplies and the exciting coil is connected in series with the primary of the engine ignition coil. When the predetermined rpm is reached, the reed resonates and allows an intermittent current to flow through a pair of adjustable contacts associated with the reed. This current may be used to operate a warning lamp, gear change mechanisms, or the like. In the latter application the resonant frequency may be arranged to vary with the manifold pressure. G. F. Byrne, 29 Kinkora Rd., Hawthorn, Victoria, Australia.

(*Continued on page 9*)

Basic Idea

SOLVES MANY REDUCER MOUNTING PROBLEMS



This trademark stands for the finest industrial gears made.

FOOTE BROS. NEW

Line-O-Motor Drive

One base supports both speed reducer and motor in this simple, practical and foolproof mounting system . . . Now you can use standard N.E.M.A. motors and make change-overs in minutes – reducing both costly down-time and motor inventory.

Line-O-Power motorized drive solves many old problems . . . and opens new fields of advanced design for new applications. Available 1-75 H. P. for all Service Classes – Horizontal, Vertical, and Vertical Extended with Foot or Flange mounting – Double or Triple Reduction units available in Ratios from 5.06:1 to 238:1.

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Better Power Transmission Through Better Bears

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Dept. W

Write for your Line-O-Motor Catalog today

Developments to Watch

PROGRESS IN FERRITES AND TRANSISTORS . . . .

. . . . was revealed by the Sylvania Electronic Defense Lab., Mountain View, Calif., with the announcement of a ferrite image rejection filter, a device used in microwave receivers to eliminate the reception of signals at undesired frequencies. The ferrite filter is said to be an improvement over those previously used in that it can be electronically tuned at a very fast rate. Also, a new ferrite "doubler" can be used to put out powers of sufficient magnitude for systems operating at a frequency double that originally put in. New uses for lowpower transistors in switching applications for computers have been found transistors were considered permissible for this purpose.

ONE-FOURTH THE COST OF A TUNGSTEN CARBIDE TOOL . . . .

. . . . a cutting tool made of Sintox, a new synthetic material, is said to be able to operate over a wider range of conditions, last longer, cut metal more rapidly than other available tool materials, and machine some of the new "wonder" alloys and plastics. Now being made by the Sintox Corp., Allentown, Pa., common, cheap oxides, are converted into a material of unusual chemical, thermal, and electrical properties, by a special process. Discovered while searching for a more efficient insulating material, the first use of the new material was to replace porcelain in sparkplugs. Batches produced for electronic applications indicate that its dielectric strength is twice that of porcelain.

DO NOT EXPECT ANY MIRACLES FROM TITANIUM . . . .

. . . . the material that is being touted as the miracle metal. That is the conclusion of a survey conducted by Armour Research Foundation of the Illinois Institute of Technology for the Titanium Metallurgical Lab., Columbus, Ohio. The survey was to determine the applicability of titanium in gas turbines for use in airplanes. The future use of titanium in aircraft engines may be limited to parts toward the front end of the compressor where temperatures are within its range. Experience to date indicates that weight reduction can be achieved on parts operating at temperatures up to 750 F. While work is being done to develop high temperature titanium alloys, there is little likelihoood that they can be used above 1200F.

AND IN ADDITION . . . .

. . . .Next year's television picture tubes will have an opening angle of 110 deg compared to today's 90 deg tube; this will give the same sized picture screen, while shortening the depth of the set by 4 or 5 in., according to a General Electric executive. . . . The University of Michigan is installing an RCA compatible color television system for use in teaching surgical and clinical procedures to students . . . . Doctors Frederick Seitz and E. P. Wigner, professors at the University of Illinois, and Princeton University, respectively, have announced that copper can be hardened to a high degree by bombarding it with high speed nuclear particles in a reactor; further application of this process would make copper extremely brittle. . . . The nickel shortage will be around for some time, according to the Commerce Dept.; fast tax write-offs are being offered by the ODM in an attempt to get industry to expand; development of Cuban ores is possible if it is apparrent that Canada cannot supply all of this country's needs . . . .Dow Chemical Co., Midland, Mich., says that its HK31A magnesium-thorium sheet is available in adequate stocks to permit immediate delivery; containing thorium, zirconium and manganese in various combinations, HK31A has good short-time properties up to 800 F and long-time properties up to 600 F; rolled in gages from 0.016 to 2 inches.

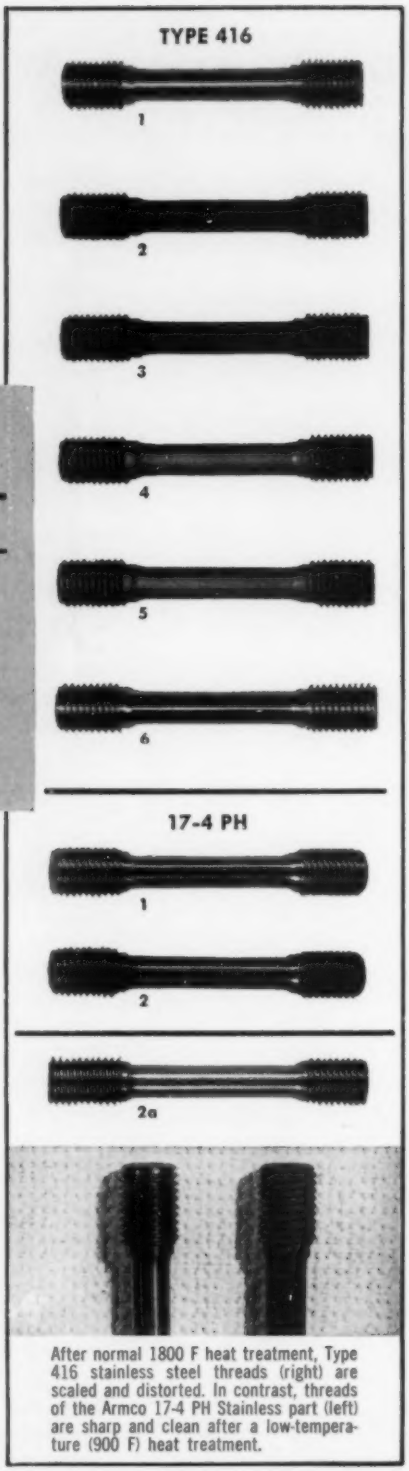
How Armco 17-4 PH Stainless

may help you eliminate

4 costly shop operations

Steps in Production of Specimen Parts With Same Tensile Properties

Type 416 Stainless Steel	Armco 17-4 PH Stainless Steel
1. Rough machining	1. Finish machining
2. High temperature heat treatment—about 1800 F	2. Low temperature heat treatment—850 to 900 F
3. Stress relieving	2A. Light pickle (needed only when appearance is vital)
4. Pickle	
5. Straightening	
6. Finish machining	



After normal 1800 F heat treatment, Type 416 stainless steel threads (right) are scaled and distorted. In contrast, threads of the Armco 17-4 PH Stainless part (left) are sharp and clean after a low-temperature (900 F) heat treatment.

If you machine stainless parts that must have high strength and hardness, here's a special Armco Stainless Steel that can cut as many as four operations from your shop practice.

It's Armco 17-4 PH, a special stainless steel that can be finish-machined and then hardened fully with a *low-temperature* heat treatment. *There's no scaling or distortion.* Parts can be completely finished in just two operations.

In the production of these stainless parts, for example, a switch from Type 416 stainless to Armco 17-4 PH eliminated 4 steps—stress relieving, pickling, straightening, and a final machining operation.

But that's not the whole story. Not only does the finished 17-4 PH part have the same tensile properties as the Type 416 stainless part . . . *it has better corrosion resistance.*

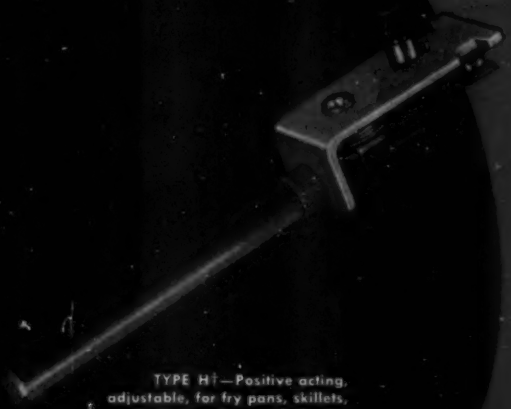
TWO PH GRADES

Armco 17-4 PH is available in billets, bars and wire. Its companion precipitation hardening grade, 17-7 PH, is produced in sheets, strip, plates, bars and wire. For full information about these special Armco Stainless Steels, just write us at the address below.

ARMCO STEEL CORPORATION

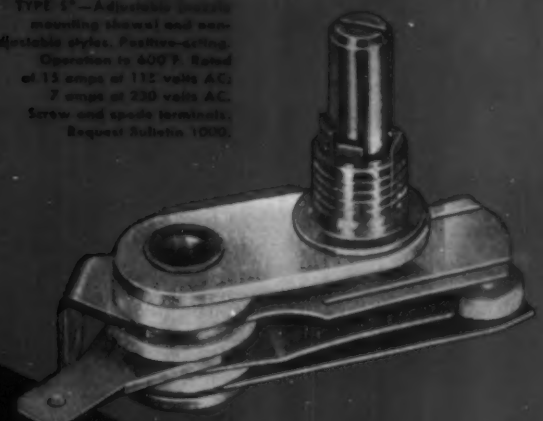
1496 CURTIS STREET, MIDDLETOWN, OHIO

SHEFFIELD STEEL DIVISION • ARMCO DRAINAGE & METAL PRODUCTS, INC. • THE ARMCO INTERNATIONAL CORPORATION



TYPE H†—Positive acting, adjustable, for fry pans, skillets, and other appliances. Fail-safe, open in low to 500 F in high. Rated at 1650 watts at 115 volts AC. See Bulletin 10,000.

TYPE S*—Adjustable bushing mounting shown; and non-adjustable styles. Positive-acting. Operation to 600°F. Rated at 15 amps at 115 volts AC; 7 amps at 230 volts AC. Screw and spade terminals. Request Bulletin 1000.



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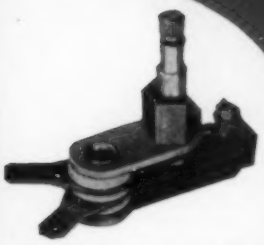
STEMCO THERMOSTATS

give you more of what you want most



TYPE SA*—Adjustable (shown) and non-adjustable. Snap acting with electrically independent bimetal. Also single-pole, double-throw. Non-inductive-load rating 15 amps at 115 volts AC; 10 amps at 230 volts AC. Spade or screw terminals. Request Bulletin 2000.

TYPE A*—Semi-enclosed. Insulated, electrically independent bimetal disc gives fast response and quick, snap-action control. Operation from –10° to 400°F, or higher on special order. Various mountings and terminals. Rated at 6½ amps at 115 volts AC, 4 amps at 230 volts AC and 28 volts DC. See Bulletin 3000.

Features such as snap or positive-action . . . various terminal arrangements or mounting provisions . . . different temperature ranges—there's a *standard* type Stemco thermostat for your *special* needs. That means you cut down on lead time, research and development costs, tooling and production inventory. Specify Stemco and you get *better thermostats, faster and for less* than you can make them or buy them elsewhere.

TYPE [illegible] surface-mounting sensors on other surfaces and warm air applications. Snap-acting d'sc type U.L. approved for operation to 300°F. Rated at 25 amps at 120-240 volts A.C. Open or enclosed styles. Request Bulletin 8000.

Size and weight are particularly important in appliance and apparatus applications. And here Stemco thermostats score, too. Their compactness and lightness give a better product without sacrificing performance.

Economy of mass production of many standard Stemco types with literally hundreds of terminal arrangements and mounting provisions means your product costs less to make, is easier to sell.

Availability of most types is good. Design is flexible for your special applications, tooling is in existence for short-term delivery. If heat control is your problem, Stemco thermostats can provide the answer.

AA-0761

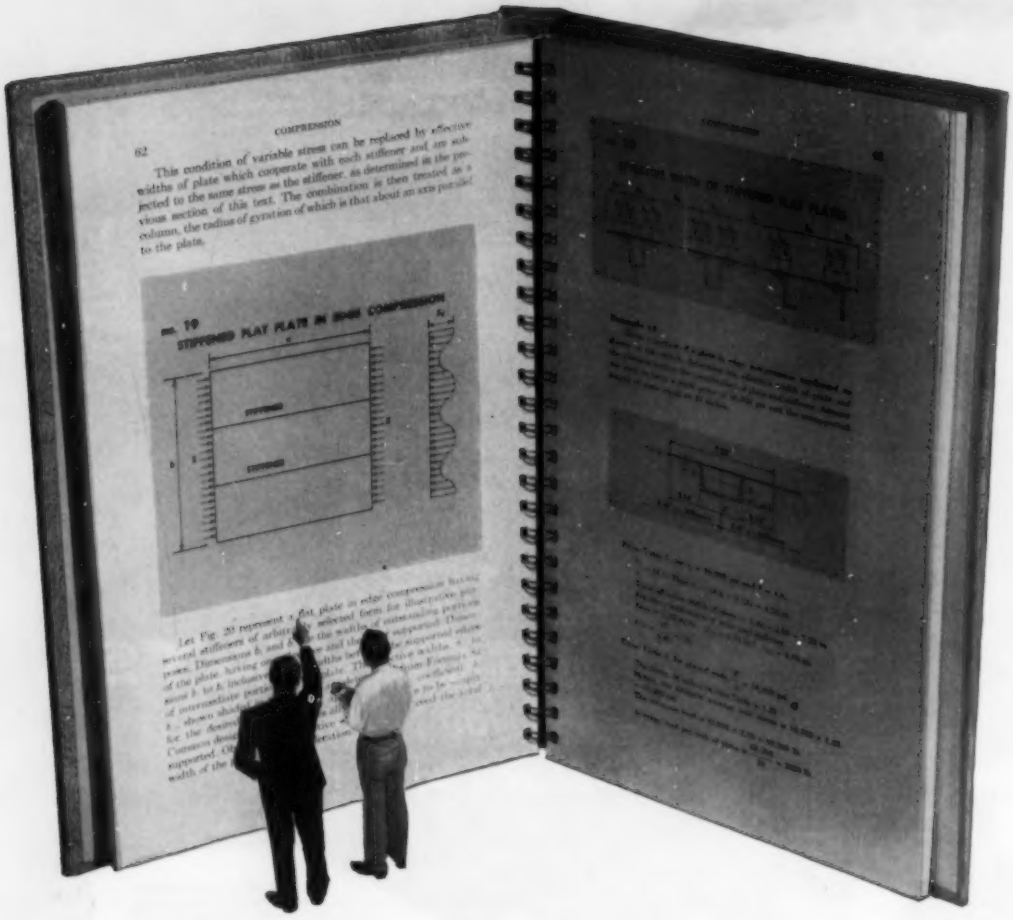
*Refer to Guide 400 EO for U.L. and C.S.A. approval ratings.

†Patent Applied for

STEMCO THERMOSTATS

[redacted] manufacturing company, inc.

Lexington and Mansfield, Ohio


62 COMPRESSION
This condition of variable stress can be replaced by effective
widths of plate which cooperate with each stiffener and are sub-
jected to the same stress as the stiffener, as determined in the pre-
vious section of this text. The combination is then treated as a
column, the radius of gyration of which is that about an axis parallel
to the plate.
STIFFENED PLAT PLATE IN EDGE COMPRESSION

You'll find it all here...

The information you need when designing for high strength steels

OUR new "Design Manual for High Strength Steels" is ready for distribution. Here are 174 pages of practical, authoritative information that you will find invaluable in designing your product for greater economy and efficiency by the sound use of high strength steels. No designer should be without it.

This excellent book covers in detail the problems of tension, compression, shear, beam stress, deformation and deflection. It fully describes the fundamental characteristics of low-alloy high strength steels, shows you how to design against corrosion, describes the application of formed sections. Complete with tables, formulas, and basic data covering this important field of design.

• • •

For your free copy, write on your company letterhead, giving your title or department, to United States Steel Corporation, Room 5463, 525 William Penn Place, Pittsburgh 30, Pa.

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USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

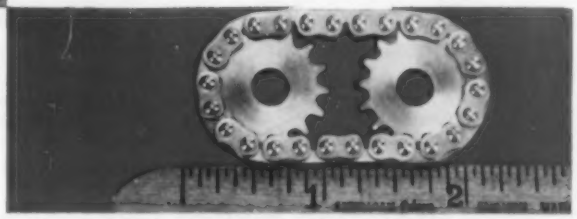
UNITED STATES STEEL

Here's full-scale efficiency in a fractional hp drive

CHAIN AS SMALL AS THIS

SPROCKETS AS SMALL AS THIS

A COMPLETE DRIVE AS SMALL AS THIS



LINK-BELT 3/16-in. pitch Silent Chain is smooth, quiet, positive at high or low speeds

Here's the ideal drive for limited-space applications. Despite its pitch of only 3/16 inches . . . weight as little as .07 pounds per foot — this durable Link-Belt drive is better than 98% efficient. In fact, it often replaces expensive, precision-cut gear trains.

It's available in carbon and stainless steels . . . for ratios up to 12:1, speeds over 7500 rpm. Book 2510 explains outstanding features, including tooth and link form which eliminates chordal disturbance. Write for your copy to LINK-BELT COMPANY, Dept. 316, Prudential Plaza, Chicago 1, Illinois.

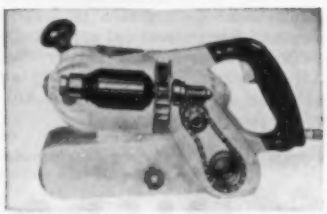
LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

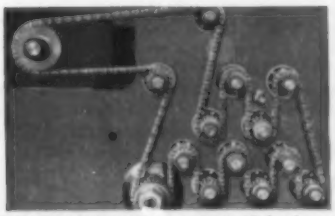
Link-Belt 3/16-in. pitch silent chain is installed as original equipment on

aircraft	portable planers
bread slicers	portable sanders
button making machines	radar equipment
cameras	recording machines
cigar making machines	rubber slicing machines
looms	sealing machines
meters	sewing machines
motion picture machines	timing devices
oil burners	typewriters
packaging machinery	vending machines

ACCURATE POWER FEED for contour shaping machine is assured by Link-Belt 3/16-in. Silverstreak silent chain.



POSITIVE POWER TRANSMISSION by Link-Belt 3/16-in. silent chain drive aids portable belt sander efficiency.

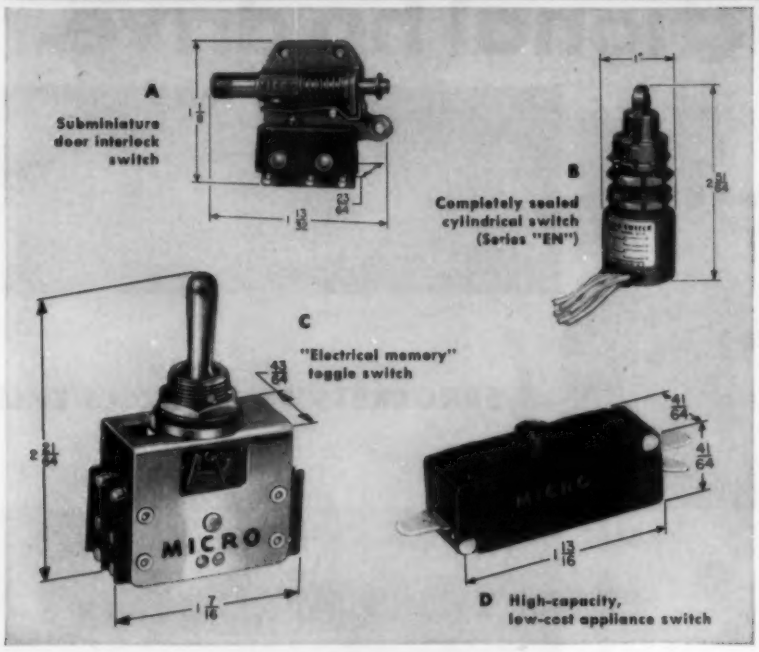


PERFECT SYNCHRONIZATION of intricate 14-wheel drive is maintained by Link-Belt 3/16-in. Duplex silent chain.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,251

MICRO precision switches

...THEIR USE IS A PRINCIPLE OF GOOD DESIGN



See the unusual design flexibility of the new MICRO Series "EN" switches

Spring return adjustable actuator for cam or slide actuation
Roller plunger actuator for actuation by cams and slides

A continuous flow of Precision Switch Developments anticipates Your design needs

MICRO precision switches are developed and built to meet specific requirements. Some designs call for the utmost precision, plus reliability. Other designs put long life and extreme reliability at the top of the list. Some must have all of these and more. Whatever YOUR requirement may be, MICRO SWITCH has a switch readily available or can work with you in its development.

Here are a few recent MICRO SWITCH *developments to meet specific needs:*

A The subminiature door interlock switch is for use where an extremely small assembly is desired to provide automatic cut-off of the power circuit when a cabinet door is opened. This switch assembly has been found extremely valuable on radio, radar, x-ray and other hazardous equipment where it is desirable to provide automatic protection to operating personnel. (*Ask for Data Sheet P108*).

B The MICRO SWITCH "EN" Series switches are capable of reliable, long-life performance under extreme environmental and mechanical conditions. They are completely sealed, cylindrical in shape and can be mounted wherever a through hole can be provided. Variations of the "EN" are capable of actuation by almost any means (see right hand column). (*Send for Data Sheet 105*).

C This is the first of a new series of "electrical memory" toggle switches being introduced by MICRO SWITCH. They offer a completely new concept in switching remotely controlled circuits. They promise to simplify basic circuit designs of radar units, computers, aircraft control panels and similar devices. The switch indicates through a pilot light or buzzer which circuit was last actuated. (*Send for Data Sheet 109*).

D MICRO SWITCH now offers a new series of low cost plastic encased switches especially designed for use on domestic appliances. In addition to their small size and high electrical capacity, these switches are ruggedly constructed for hard service. They are readily adaptable for use with auxiliary actuators. (*Send for Data Sheet 106*).

MICRO SWITCH *Engineering service is available at nearby branch offices. A call can save you time and money.*

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

Effective sealing with confined resilient gaskets

In order to seal a metal-to-metal joint effectively, a gasket must meet at least two basic requirements. It must completely fill the recessed gasket channel to provide maximum contact with the mating flange . . . and it must be able to be compressed sufficiently to prevent leakage of the sealed medium.

cork-and-rubber gaskets

Both of these needs can be met with gaskets cut from truly compressible materials such as cork-and-rubber composition. (If non-compressible rubber gaskets are used, either relief must be provided for sideflow, or the gasket must be cut so that its volume does not exceed that of the cavity. Also, the initial shape of a rubber gasket must permit 20 per cent deflection when the joint is closed.)

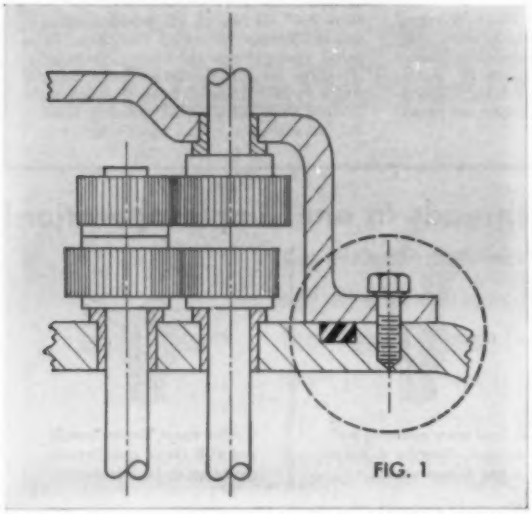


FIG. 1

filling the channel

To fill a channel completely, cork-and-rubber gaskets are cut to full channel width and, depending on their degree of compressibility, from 1.25 to 1.5 times channel depth. Because these cork-and-rubber gaskets actually decrease in volume under load, they do not require relief for sideflow or excessively close gasket and metal tolerances.

correct compression

Correct gasket compression is also assured with the right cork-and-rubber composition. Each cork-and-rubber material combines precisely controlled amounts of truly compressible cork and non-compressible synthetic rubber. As a result, a cork-and-rubber gasket can provide a pre-determined degree of compressibility to handle the required flange load.

typical applications

Typical of the metal-to-metal sealing jobs done by cork-and-rubber gaskets is the instrument housing flange shown in Figure 1. Completely confined, the cork-and-rubber gasket prevents leakage of the lubricating oil and permits perfect alignment of the gears.

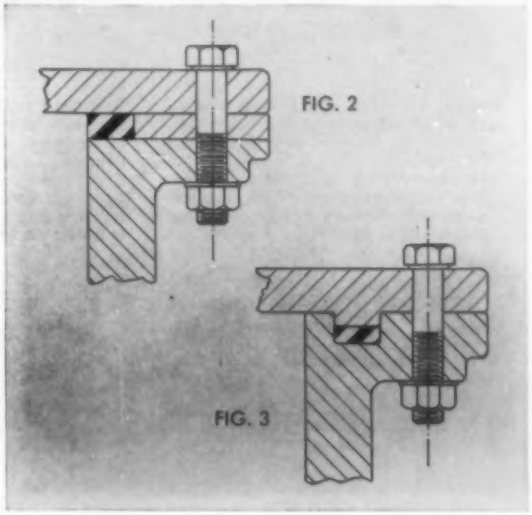


FIG. 2

FIG. 3

In Figure 2, flat flanges were adapted to metal-to-metal sealing by the insertion of an annular shim. Here, the cork-and-rubber gasket compresses to form a tight seal without tending to flow out of position.

The high pressure metal-to-metal flange shown in Figure 3 utilizes a stop to prevent blowouts. By completely filling the confined channel, cork-and-rubber maintains a tight seal.

SEND FOR 24-PAGE GASKET DESIGN MANUAL

You'll find other useful information on the design and use of gaskets in the new Armstrong Gasket Design Manual. Write for your copy to Armstrong Cork Company, Industrial Division, 7110 Irvin Street, Lancaster, Pa. For information on all Armstrong Gasket Materials, see Sweet's product design file.

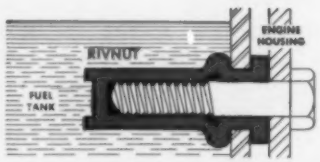
Armstrong

GASKET MATERIALS

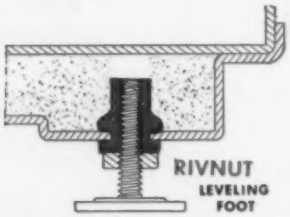
. . . used wherever performance counts

B.F. Goodrich Rivnut

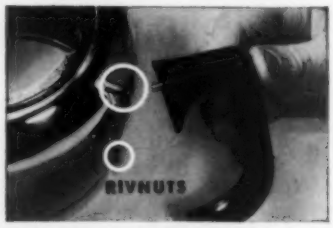
solves practically any fastening problem



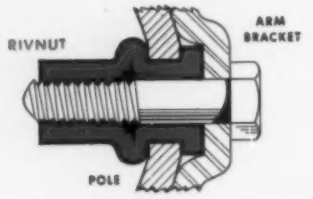
MAKES NUT PLATE, SEAL. Quickly installed in gas tank wall, Rivnut makes firm, accurate nut plate that can't be loosened by shock or vibration. At least six threads are clean for bolt attachment to engine housing. Straps, rivets, braces, nuts are eliminated. Rivnut's special closed end makes 100% gasoline-tight seal.



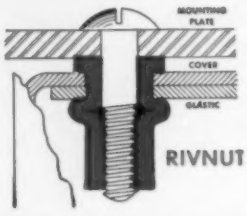
NEW WAY TO FASTEN LEVELING FEET. Appliance manufacturers install Rivnut in metal too thin to tap or weld *after* enameling. Bulge in Rivnut shank (second head) firmly grips the material. At least six threads remain clean to take the leveling foot screw—more than enough to handle the weight of heavy appliances.



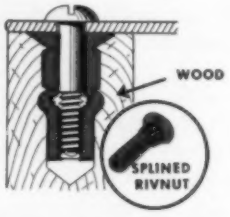
SPEEDS HANDLE ASSEMBLY. B. F. Goodrich Rivnut saves time fastening handle to small appliance. It provides a strong nut plate in *seconds*. Replaces slower fastening methods like nuts and bolts, welding, clinching, tapping. Rivnuts can be installed from one side and the open end types can take an attachment screw from either side.



CUTS ASSEMBLY COSTS 50%. In a street light application, it took two men to fasten the arm bracket to the pole. Then the manufacturer redesigned the unit to use Rivnuts. Now one man can do the job in the same time. Tests show the pole or arm bracket will fail before the Rivnuts.



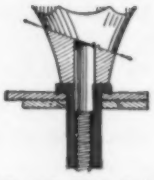
DOES TWO FASTENING JOBS. Rivnuts simplify transformer assembly from start to finish. Starting with unassembled parts, worker fastens sheet of plastic to metal cover with Rivnuts. With cover secured to frame, the Rivnuts then serve as mounting plate.



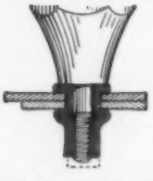
NEW WAY TO FASTEN TO WOOD. Special splined Rivnut for solid fastening in wood eliminates wood screws, provides six metal threads for attachment bolt. Bulge formed in shank holds Rivnut fast. Splined shaft keeps it from turning. Used for bus seats, metal backs in TV sets, etc.

How Rivnuts provide at least 6 clean threads in one simple operation!

1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work—tool at right angles to work.



3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

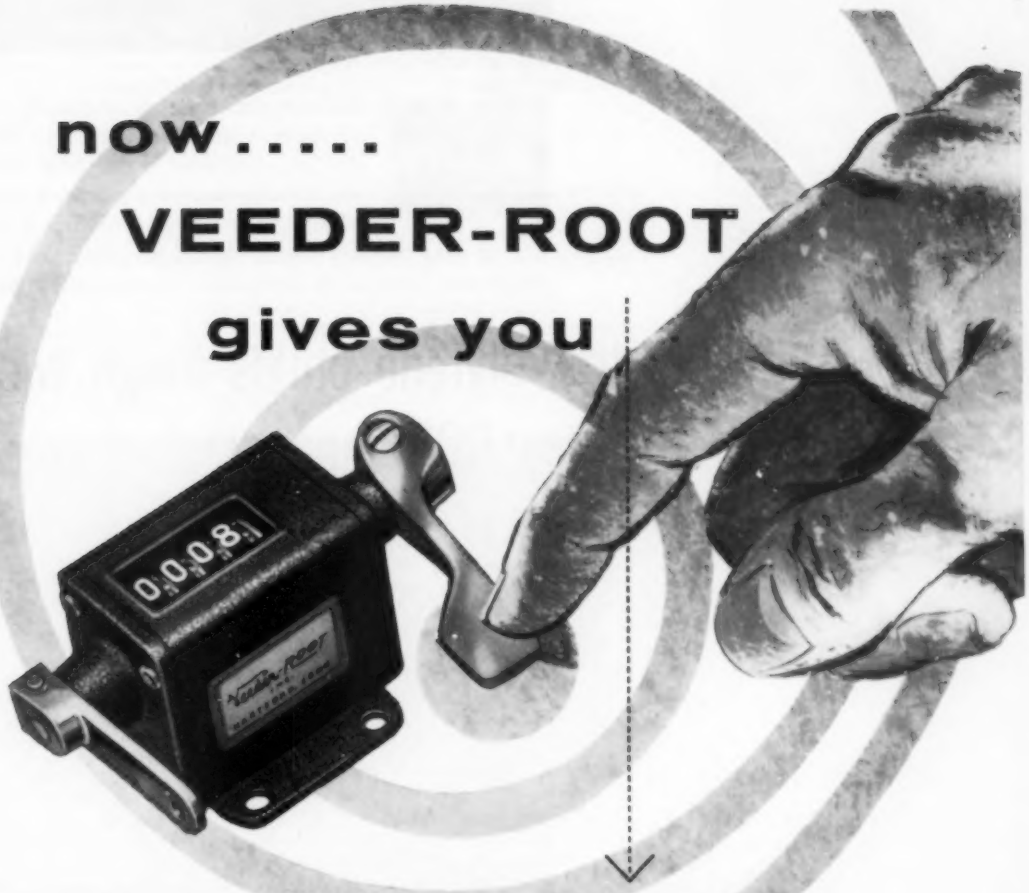
SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO and WITH. Explains construction, simplicity of installation. Get your free copy by writing to: The B. F. Goodrich Company, PE-106, Akron, Ohio.

B.F. Goodrich RIVNUTS

The only one-piece blind rivet with threads

now.....
VEEDER-ROOT
gives you



instant "push-button" resetting

Just press the easy-acting lever on this Quick-Reset Ratchet Counter . . . *and all 4 figures reset to zero as instantly as though you used a push-button.* This saves time and speeds work on short machine runs, inspection and many other jobs. Counter is compact . . . 2.69" long, 1.44" high, 1.29" wide. The 4 white-on-black figures are .166" high. You can order it (Series 1126) from stock right now . . . just like scores of other Veeder-Root Counters for manual, mechanical and electrical operation in every field from electronics to atomics.

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VEEDER-ROOT
"THE NAME THAT COUNTS"

Craftsmanship of the 20th Century

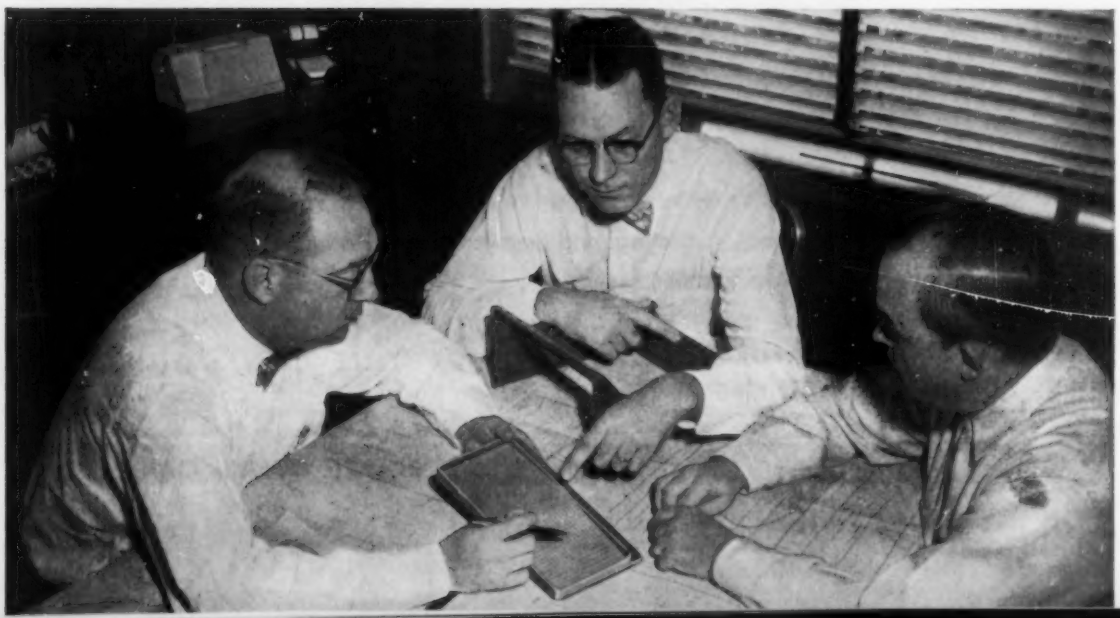
MONSANTO

To meet the challenge of making each year's products more serviceable, more saleable than the last, designers in one case after another are enlisting the aid of plastics engineers. This picture-story tells how craftsmen of the custom molding industry utilized the unique properties of plastics to design and fabricate the cabinet for a famous name phonograph.

Lustrex® styrene builds tough two-tone "home" for new RCA phonograph

DESIGN OBJECTIVE. RCA envisioned a one-piece two-colored cabinet—5½" deep, 11" long and 10¼" wide—for its new table model phonograph. It was to be highly durable, low in cost, light in weight, and "custom cabinet-like" in workmanship.

MATERIAL SPECIFICATIONS. The assignment was turned over to Cambridge Panelyte Molded Plastics Company, Cambridge, Ohio. Working from a wooden mock-up, these custom molders arrived at one immediate conclusion: there was no practical way to mold the base and grill as a single unit—and still control the duality of color specified by RCA. This meant that, added to other material specifications, there was the need for a material that would allow solvent-cementing assembly of the two parts. Other points to be considered in the selection of the right material included intrinsic hardness, fracture potential in movement, finish, moldability into intricate involutional patterns, and color choice. This last requirement pointed directly to styrene which was found to be completely adaptable to the unusual color combinations requested by RCA designers. In addition, styrene offered excellent moldability of shallow cavities, beveled areas, and the symmetrical line face of the grill section.



PRODUCTION. Length of time required for getting a new model into production is always an important consideration. In this case, there was a minimum of delay between design and production. Cambridge Panelyte drew up final plans within 2 weeks, made the production mold inside of 3 weeks. Monsanto Lustrex styrene was selected for its flow characteristics that permitted high production cycles to be set and maintained on 32 oz. and 12 oz. injection molding machines. High impact Lustrex also provides the resilient toughness required for the grill and body.

THE FINISHED PRODUCT. The new RCA phonographs now on the market are enjoying a solid sales success. One of the factors in their universal acceptance is their strikingly handsome and lustrous cabinets of "pearl gray" and "flame red," molded in fine detail of Monsanto Lustrex styrene plastic.

This is one of hundreds of design and production problems solved through the facilities and craftsmanship of the plastics custom molding industry. Monsanto will be glad to direct you to qualified molders who can help you in your new product design or improvement. Write to Monsanto Chemical Company, Industrial Applications Dept., Springfield 2, Mass.

Investigate Monsanto's completely balanced line of styrene formulations developed for particular applications and sold under the trade name . . .

LUSTREX
Styrene Plastic

MONSANTO

by Carl F. Joseph
Technical Director

CENTRAL FOUNDRY DIVISION
GENERAL MOTORS
CORPORATION

.....The metallurgy of strength and

The secret of a stronger iron casting lies in the composition, the melting and the heat-treating processes. Perhaps I should use some other word than "secret," because the fact is well known today, but in 1925, when we started our search for a stronger iron, the principle was well known only in respect to steel.

Our research led us to think that heat-treating could improve iron as well. After considerable experimentation, we learned how to arrest the malleablizing process to produce an improved pearlitic malleable iron . . . an iron that compares favorably with the properties of a good grade forged steel. It is from the words "Arrested Malleable iron with Steel-like characteristics" that the name "ArmaSteel" was coined.

The raw materials and melting process for ArmaSteel are very similar to those of our malleable iron . . . the major difference being in the heat-treat cycle. In the cupola, we melt steel scrap, ferrosilicon, and remelt. We add .0025% boron to the charge to assist in breaking down carbides during malleablizing.

Next, the molten iron is tapped into a forehearth where it is desulphurized with soda ash. This removes small particles of slag and impurities, thus improving machinability of the casting. After refining in an electric furnace, the iron is tapped into ladles.

To improve the physical properties on certain castings, .007% bismuth is added as a ladle inoculant: this stabilizes the carbides during the initial freezing of the metal. On heavy castings such as the Pontiac crankshaft, up to .02% bismuth is added. This bismuth-boron combination is a new development.

I mentioned before that the heat-treating of ArmaSteel greatly affected its properties. Actually, we use several different heat-treatments to produce the several ranges of ArmaSteel. All are alike during the malleablizing cycle, where the massive carbides are eliminated. Malleablizing requires about 20 hours: the castings are held at 1750°F. for 10 hours, and near the end of the cycle are dropped to 1650°F., after which they are air-quenched. Brinell hardness at this point is around 300.

Tempering brings the Brinell hardness down to customer's specifications. We produce two standard Brinell ranges of air-quenched and tempered ArmaSteel . . . BHN 197 to 241 (3.9-4.3 mm.), and 163 to 207 (4.2-4.7 mm.). The castings are tempered in a recirculating furnace. The harder material is in the furnace for a total of six hours and forty minutes, and is held at heat for three and one half to four hours at 1270° to 1290°F. The softer material uses the same time cycle but higher heat . . . from 1320° to 1340°F.

For automobile crankshafts, a special hardness range is used. The ArmaSteel is air-quenched and tempered, but the tempering is for six hours at 1200°F., which produces a harder material (BHN 217 to 269).

Two other types of ArmaSteel are produced by reheating the air-quenched castings to 1600°, holding at heat for thirty minutes, then oil-quenching. These are then tempered for three and one half hours at 1170° to 1190°F. BHN is 241 to 260 (3.7-3.9 mm.) and 269 to 302 (3.5-3.7 mm.).

I've gone into detail on heat-treating because it has such a great effect on mechanical properties. Tempering directly controls the amount of combined carbon in the matrix, and this in turn dictates how hard and strong the ArmaSteel will be . . . the higher the combined carbon, the stronger, harder, and less ductile the casting. Thus, the engineer can choose the combination of properties best suited to his application. I can best explain the results of this careful heat-treatment by giving you a brief list of the mechanical properties of ArmaSteel.

1. *Machinability* . . . Because of the carbon nodules in the pearlite matrix, the machinability of ArmaSteel is generally from 10 to 30 percent better than that of steel forgings of the same Brinell. Improvements of up to ten times longer tool life and three times more pieces per machine have been shown.

2. *Selective Hardening* . . . ArmaSteel responds readily to localized hardening, either by flame or induction methods. A minimum of Rockwell "C" 50 is obtainable on such parts as shifter yokes, rocker arms, and gears. Some applications use the lead immersion or hot salt bath methods, followed by an oil-quench.

3. *Bearing Properties* . . . ArmaSteel is such an efficient bearing material on a hardened steel shaft that bronze bushings are often eliminated. The automotive rocker arm illustrates this excellent non-seizing property in metal-to-metal wear.

4. *High Yield Ratio* . . . The oil-quenched and tempered ArmaSteel has a minimum yield strength of 80,000 psi and ultimate strength of 100,000 psi, making it ideal for highly stressed parts.

5. *Fine Machine Finish* . . . A mirror-like finish can be produced on ArmaSteel. Diesel pistons are an application where this fine finish reduces friction wear to a minimum.

6. *Damping Characteristics* . . . In both small engines and in automotive engines, ArmaSteel crankshafts exhibit a fine damping capacity that aids quiet operation.

7. *Wear Resistance* . . . ArmaSteel withstands excessive wear under heavy loads at high speed.

8. *Fatigue Life* . . . ArmaSteel has good resistance to fatigue, giving maximum endurance and long life.

As countless and varied applications have proven, ArmaSteel is an outstanding engineering material. For information on how your product can benefit from this modern casting metal, write for our "ArmaSteel" catalog.

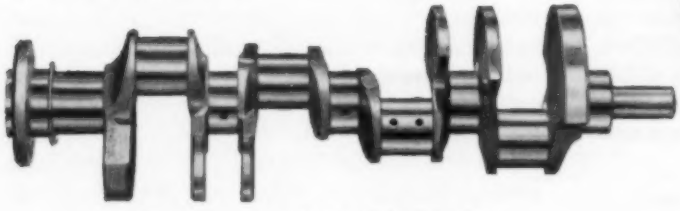
ARMASTEEL® from the standpoint of machinability

ArmaSteel small horsepower engine crankshafts provide good damping qualities and modest cost due to excellent machinability.

ArmaSteel's adaptability to localized hardening pays off especially well on these automotive rocker arms.

Universal joint yokes of ArmaSteel stand up under severe stresses to same extent as former SAE 1145 or 1151 forgings.

Because of its excellent wear resistance, oil-quenched and tempered ArmaSteel with a Brinell of 241 to 269 has replaced an SAE steel forging for this automotive reverse internal gear.



Pontiac's conversion to ArmaSteel Crankshafts doubled cutter life and speeded up by 50% the grinding of main journals.

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 10

Typical parts made of Alcoa Aluminum Screw Machine Stock by Enterprise Mfg. Co.

HOW PFLUEGER* MAKES MORE AND BETTER REELS WITH ALCOA® ALUMINUM SCREW MACHINE STOCK

Since Civil War days, 3 generations of Pfluegers have parlayed a small harness business into the giant Enterprise Manufacturing Company of Akron, Ohio . . . one of the world's foremost makers of fishing tackle. Alcoa Aluminum Screw Machine Stock has contributed to the sales appeal of Pflueger reels since 1929.

The Pflueger success story is typical of the competitive advantages frequently gained by a switch to aluminum screw machine stock. Its free-machining qualities speed production by permitting operations at maximum spindle speeds . . . with less tool breakage, fewer rejects, better finish with fewer secondary operations. It has longer tool life, provides three times as many parts per pound of metal. And abundant supplies are available.

All these solid economic advantages point up the wisdom of a hard commercial look at aluminum screw machine stock. Alcoa will provide you with technical assistance, alloys information, and the greatest store of experienced counsel available in the industry. Just call your nearby Alcoa sales office, listed under "Aluminum" in your phone book. Aluminum Company of America, 865-K Alcoa Building, Pittsburgh 19, Pennsylvania.

IN PURCHASING

Wayne Miller, Director of Purchasing, says,

"Pflueger reels have used aluminum parts since 1929 . . . and we've always bought our metal from Alcoa. Alcoa's personnel have always been most cooperative. Their shipping dates and promises always hit together. We especially like the shipping notices Alcoa forwards to us. Tolerances and composition always meet our most exacting specifications. Engineering help and warehouse service continue to keep us happy."

IN DESIGN

Mr. Tom Sarah, Chief Engineer of Design and Development, says,

"Our annual sales conference guides design policy. Customers began to insist on lightness; we were given the job of lightening up while still maintaining quality and dependability. Aluminum looked like a natural . . . and was. It takes the high-quality finish we require. It offers the corrosion resistance so essential when our reels are used in salt-water fishing. And Alcoa's research and development facilities were a great help to us in selecting proper alloys and finishes. We will be using more and more aluminum parts."

IN PRODUCTION

Garnett Young, Foreman, in discussing production with operator John Schmidt (left), says,

"Many of our workers are women and aluminum's light weight eases our materials handling. We get longer tool life and can hold closer tolerances on operations such as drilling, milling, tapping and machining. We cut fine-pitch threads and we prefer aluminum for this more than any other metal. Because aluminum is easier on tools, we get less heat and can use lighter oils. With aluminum, we have no trouble with concentricity. We run at top spindle speeds. There's less chip trouble and we get high prices for our scrap. If trouble develops, Alcoa sends engineering help to straighten us out in a hurry."

IN OUTSIDE SUPPLY

Some parts of the famous Pflueger reels are made by Locke Machine Company of Cleveland, Ohio. (Member of the National Screw Machine Products Association.) Here Mr. A. W. Glasheen, Estimator; Mr. J. E. Tomer, Vice President and Mr. E. H. Baker, Factory Manager, discuss the finish requirements of a Pflueger reel. They say, "Pflueger demands tight tolerances and a superfine surface finish. We find it easy to comply by using Alcoa Aluminum Screw Machine Stock. Tool life is good and we use extremely heavy machine feeds. Concentricity requirements are close, but we maintain them with aluminum. Our operators like to work with aluminum and we like to deal with Alcoa. Service has been extremely prompt, and their quality is excellent. We feel it is the best on the market. We have never had to reject Alcoa Screw Machine Stock

THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

Your Guide to the Best in Aluminum Value

NOW—TRANSMIT UP TO

THIS LIFE-SIZE illustration only begins to suggest the brute strength built into this tooth-grip belt with steel-cable tension member designed to drive *really heavy machinery!* Appearance doesn't tell the whole story, because, *rating for rating,* Gilmer "Timing" Belt drives are *lighter in weight* and *occupy less space** than any other form of mechanical power transmission.

Approximately 2½ times larger—and 2½ times stronger—than the standard "Heavy Duty" series, the new XX Heavy Duty drives bring to high-torque power transmission a never-before-obtainable combination of features:

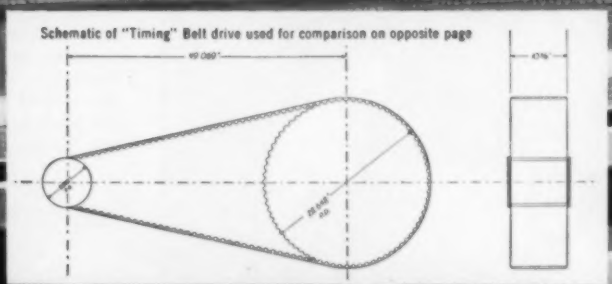
- **Highest-efficiency positive transmission of power.**
- **Complete elimination of drive lubrication (including the problems and accessories involved).**
- **Precise angular synchronization ("Timing") between two or more shafts.**
- **Practical elimination of power loss due to slippage, friction and high initial tension.**
- **Quiet operation**
- **Compactness and high strength-to-weight ratio.**
- **Belt speeds as high as 7500 fpm.**
- **Low initial cost; no maintenance; long life.**

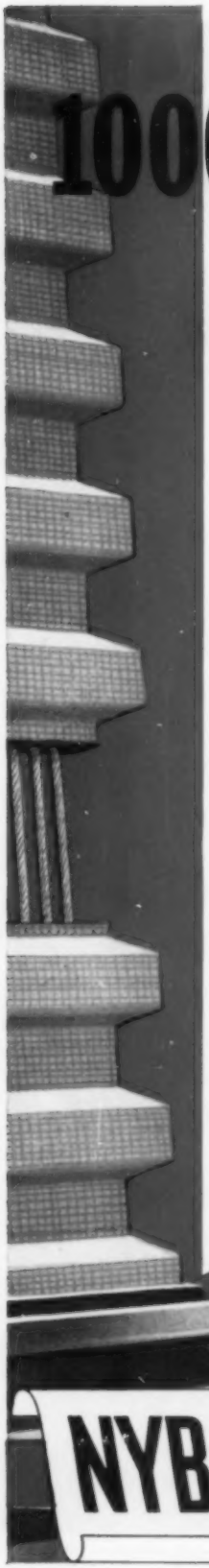
For further data on Gilmer "Timing" Belt drives—from "flea-power" to 1000 horsepower – consult your local NYB&P-Gilmer Distributor. Look for his name under Power Transmission in your classified telephone directory.

**Including accessories required by some other drives.*

Rubber cut away to show steel cables

Schematic of "Timing" Belt drive used for comparison on opposite page





1000 HP WITH THE NEW *Gilmer* XX HEAVY DUTY 1¼" PITCH "TIMING"® BELT DRIVE

TO HELP YOU COMPARE a Gilmer *XX Heavy Duty* "Timing" Belt drive with the four other common forms of power transmission of equal capacity, a power transmission engineer offers his recommendations based on published application and load ratings, for the following:

A 300-HP drive (at 1160 rpm.) including application factors
3.00: 1 speed reduction
Approximately 50" center distance

Here, complying with minimum pulley sizes and other practices commonly observed, are his recommendations (with approximate comparative cross sections of space occupied by each drive):

"TIMING" BELT DRIVE
Belt: XXH "Timing" Belt 10" wide by 160" P. L.
Motor Pulley: 9.549" P. D. (24-groove) 1¼"-pitch
Driven pulley: 28.648" P. D. (72-groove) 1¼"-pitch
Belt speed: 2900 feet per minute

V-BELT DRIVE
Belts: 10 Super Service "D"-Section V-Belts (DP-225)
Motor pulley: 18.0" P. D. x 10 D-groove, 14¾" wide
Driven pulley: 54.0" P. D. x 10-groove, 14¾" wide
Belt speed: 5380 feet per minute

GEAR DRIVE
Herringbone gear speed reducer with 3:1 ratio. (A typical reducer of required capacity weighs 1440 lb., measures 33" long, 26⅝" high and 19" wide.)

ROLLER CHAIN DRIVE
Chain: #80-8 (8 strands) 1"-pitch x 152 pitches
Motor sprocket: 7.979" P. D. (25 teeth)
Driven sprocket: 23.880" P. D. (75 teeth)
Chain speed: 2380 feet per minute
(Requires Type #3 lubrication with oil-tight case for sump pump)

FLAT BELT DRIVE
Belt: 21" wide x 8-ply x 18' 4" long
Motor pulley: 18" O. D. x 23" wide
Driven pulley: 54" O. D. x 23" wide
Belt speed: 5380 feet per minute

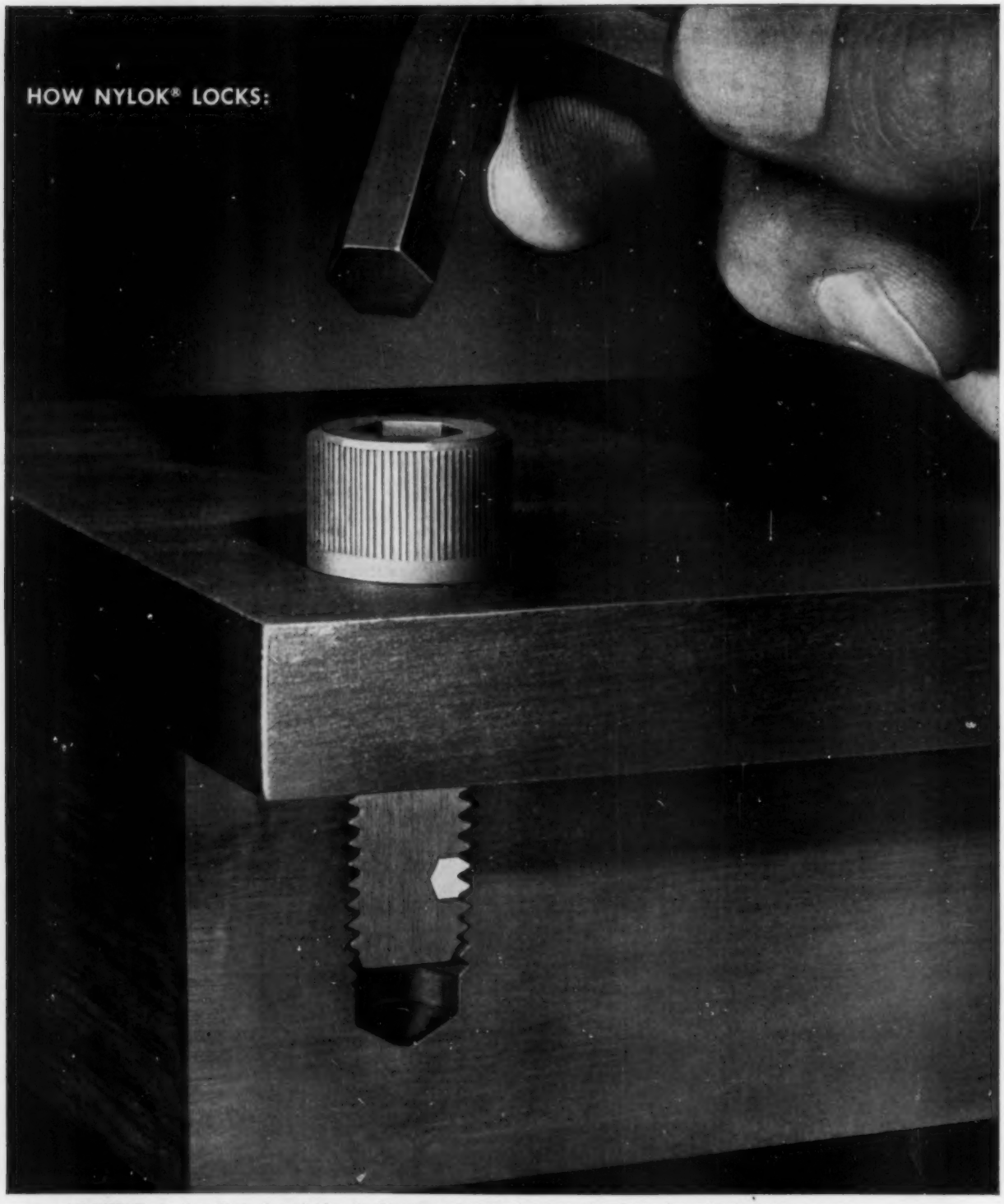
In cost and in weight the "Timing" Belt drive also has a big savings advantage. Ask your NYB&P-Gilmer Distributor for the figures.

NYB&P — NEW YORK BELTING & PACKING CO. — Founded 1846

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

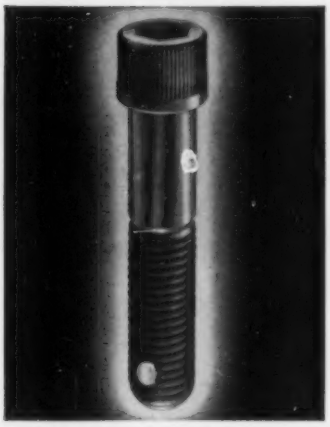
America's Oldest Manufacturer of Industrial Rubber Products

NEW—self-locking UNBRAKO



LOCKED! The tough, resilient nylon pellet keys itself into the mating threads. It forces threads together and locks the screw securely.

socket head cap screws



Self-locking UNBRAKO socket head cap screw.

BEFORE ASSEMBLY. The nylon pellet projects slightly. When assembled, threads will be impressed into it.

AFTER REMOVAL. "Plastic memory" of pellet has expanded impressed threads to greater diameter than screw threads. Screw can be used repeatedly. In use, "memory" keeps threads tightly locked.

They won't work loose. And they simplify design and save production time.

UNBRAKO socket head cap screws are now available embodying the Nylok* self-locking principle. Nylok provides the first truly practical solution to the problem of making cap screws self-locking.

An UNBRAKO cap screw with Nylok is a single self-locking unit. No auxiliary locking devices are needed. Just thread the UNBRAKO into any tapped hole. *Seated or not*, it locks positively wherever wrenching stops. The tough, resilient nylon pellet forces mating threads together and holds tight. The screw will not work loose.

You save production time when you make products with self-locking UNBRAKOS. And you get greater simplicity in design with less bulk and weight. The number of parts you must assemble to achieve full locking action is reduced to the absolute minimum. Lockwashers under screw heads are no longer necessary. Costly wiring of cross drilled heads is eliminated. And in many cases you will save weight and mass by using shorter screws in tapped holes instead of drilling through and using nuts and lockwashers.

Self-locking UNBRAKOS are reusable. They have uniform locking and installation torques—with no galling or seizing on mating threads. They successfully withstand temperatures from —70° to 250°F. And, when screws are properly seated, the locking pellet also functions as a liquid seal.

A complete line of self-locking UNBRAKO socket screw products, in a wide range of standard sizes, materials and finishes, is available through your authorized industrial distributor. Technical data and specifications are detailed in Bulletin 2193. Write us for your copy today. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

**T.M. Reg. U.S. Pat. Off., The Nylok Corporation*

UNBRAKO SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

Housewares

Builder's Hardware

Appliances

Hospital, Institutional and Restaurant Equipment

Look what they're designing and fabricating from the New 200 Series Stainless Steels

Truck Trailers

Domestic and Industrial Sinks

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

Automotive Parts and Trim

Favorable reports on the fabrication of A.I.S.I. Types 201 and 202 are flowing in from manufacturers of a wide variety of stainless steel products ranging from sinks and housewares to hub caps and trailer trucks.

These reports clearly indicate that the 200 series can be fabricated on present equipment without difficulty—without any additional investment in tooling, in most cases. And possibly at savings in certain operations. In fact, skilled equipment operators—the men who work with stainless day after day—have been unable to distinguish between the 200 series and other types when they were intermixed in production runs.

The 200 series is a relatively new member of the family of Republic ENDURO® Stainless Steels. It offers high strength, corrosion-resistance, and easy formability, including draw-bench forming, roll forming, brake bending, blanking, stamping, embossing, trimming, deep and shallow drawing, welding.

Consideration of 201 and 202 for design and fabrication of your present or projected items should be based on the merits of these two types and not as alternates for other grades. However, they are being used interchangeably with other grades.

Our booklet, No. 735, has the latest information on the properties, test evaluations and potentials of these new austenitic stainless steels containing 17% Cr—4% Ni—6% Mn and 18% Cr—5% Ni—8% Mn. Republic Stainless Steel metallurgists and specialists are ready to help you apply Types 201 and 202 to your production. There's no obligation. Just send the coupon to let us know if you would like a representative to call at your plant.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
Dept. C-2518
3150 East 45th Street
Cleveland 27, Ohio

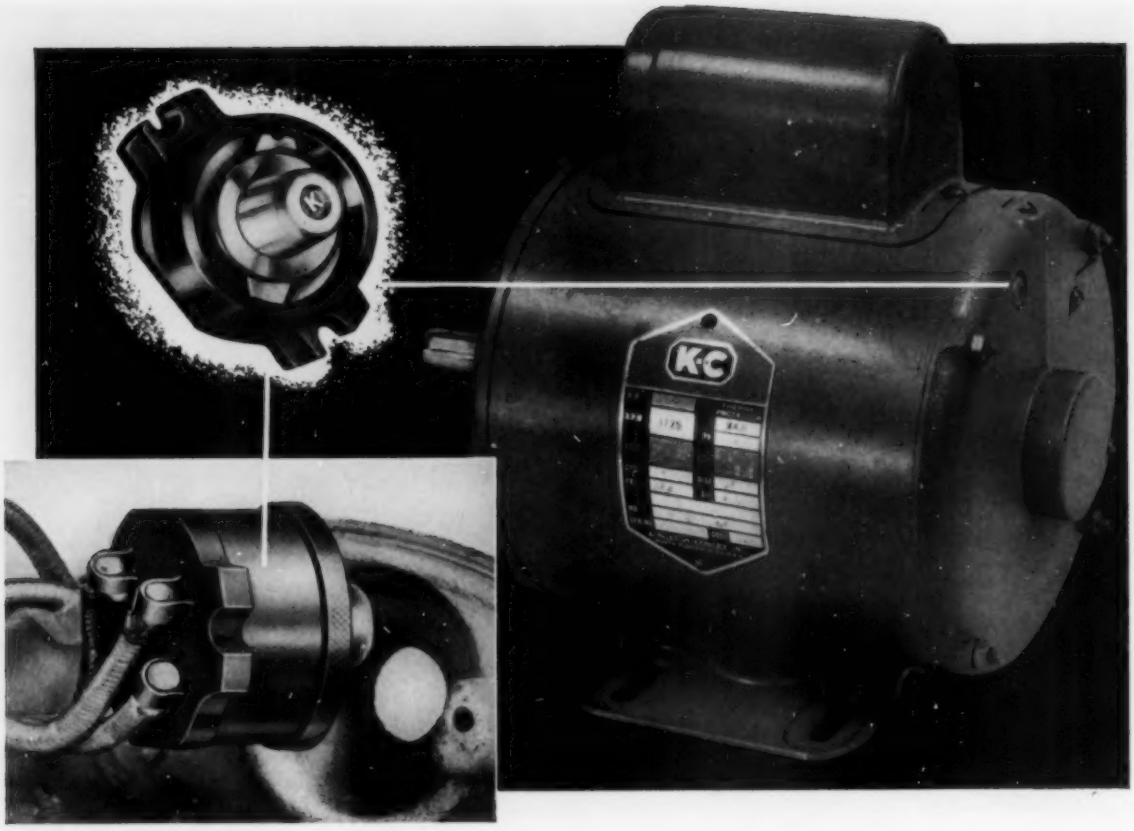
☐ Send Republic Booklet No. 735 on 200 Series.
☐ Have a Stainless Steel Metallurgist call.

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____



"This is just one of our many motors which use Built-in KLIXON Automatic or Manual Protectors"

. . . says Leading Motor Manufacturer

Kingston-Conley have been manufacturing quality electric products, including their well-known K-C line of motors, for over 20 years.

Talking about the K-C 1 hp, 1725 RPM, single phase, 115/230 volt (shown above) which is used on automatic poultry feeders, E. P. Codling, Manager of Engineering and Manufacturing says:

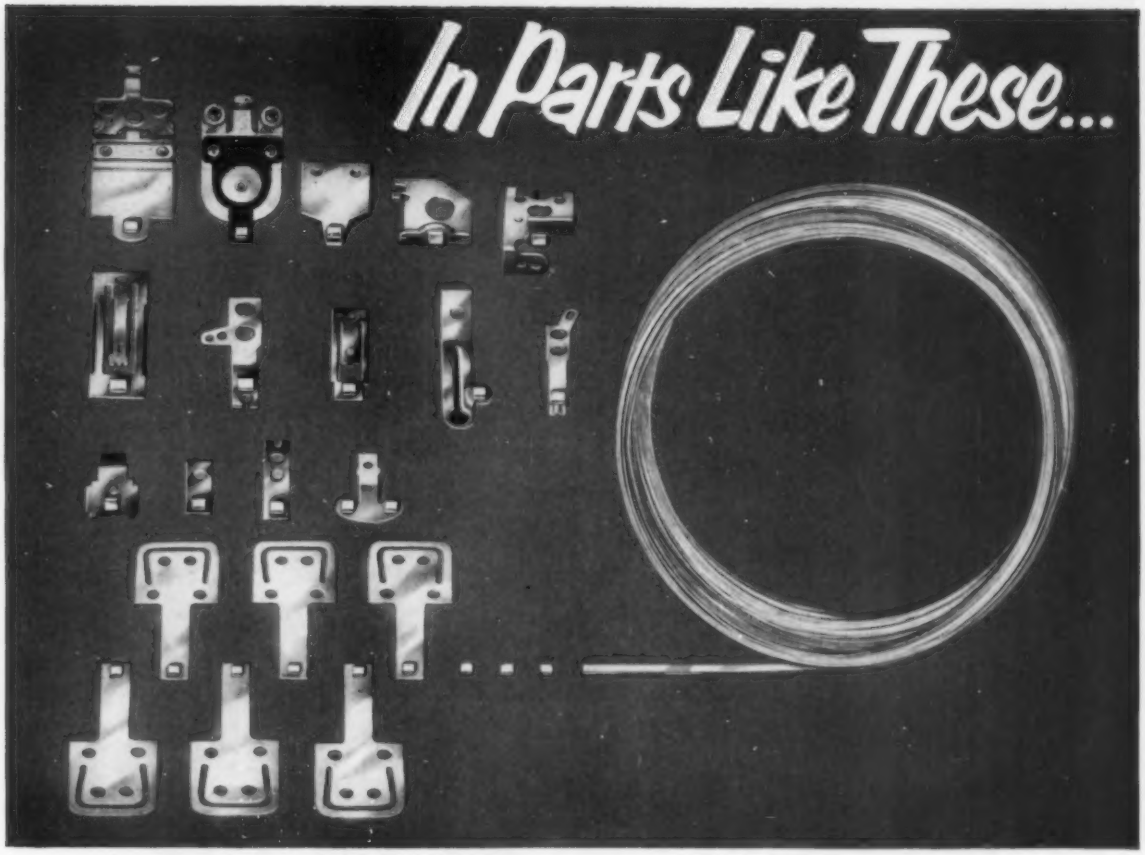
"This and many others of our motors are protected against burnouts by Klixon Protectors. Our experience has shown these Klixon Protectors to be dependable for all applications of our motors."

You, too, can keep motors in your equipment operating dependably, reduce service calls and repairs by specifying and using Klixon Protectors. The additional cost is low, pays for itself over and over by protecting against motor burnouts and unnecessary equipment shutdowns.

KLIXON®

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
3810 FOREST STREET, ATTLEBORO, MASS.

New There's Something New — In addition to the famous Klixon Protector for single-phase motors, you can now get full protection engineered into 3-phase motors with a single, built-in Klixon Protector. For full details write for Bulletin MOPR1.



GENERAL PLATE...

Clad Electrical Contact Tapes

Reduce Costs, Minimize Assembly Operations, Permit Miniaturization and Improve Performance

Included among the many advantages offered by the use of General Plate Clad Electrical Contact Tapes are assembly accuracy, change-over ease, design freedom, *plus* immediate and substantial cost reductions, performance improvements, miniaturization and standardization.

Basically, electrical contact tape consists of an electrical contacting face of desirable composition and contour plus an elevated or serrated backing of readily electro-weldable material. The serrated back makes possible a larger weld area assuring much greater thermal and electrical conductivity from the contact to backing member assuring exceptional performance.

The contact face is available in practically any ductile contact material either as a single metal or clad to another metal. Contact backing or supporting materials are available in steel, brass, copper, phosphor bronze, beryllium copper, nickel or monel, and aluminum.

Why not find out how you can benefit with General Plate Clad Electrical Contact Tapes? Write for complete information, or better still, ask for a General Plate Engineer, who will gladly help you with your contact problems.

You can profit by using General Plate Composite Metals!

METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
1010 FOREST STREET, ATTLEBORO, MASSACHUSETTS

THIS IS CYPAK

to eliminate maintenance on industrial control

Now you can break the downtime barrier to further expanding industrial control. Westinghouse CYPAK* provides two bold, new advantages to jump the limitations of mechanical relays.

First, unlike the mechanical relay, CYPAK has no moving parts to wear, corrode, jam or otherwise cause failure. Data processing is carried out by magnetic "make and break" of currents giving CYPAK a life at least 15 times that of conventional relay systems.

Second, CYPAK is given greater protection against the mechanical shocks and corrosive elements of industrial applications. Each component panel is sealed in a solid block of plastic. CYPAK systems are built up from an enclosed power channel into which the CYPAK elements are *plugged in, locked in* securely. Signal terminals are joined with push-on sleeve connectors.

But get all the facts on the challenging advances made in CYPAK. Call your Westinghouse sales engineer today.

J-01004

*Trade-Mark

Write today for your free copy. *The Whys and Wherefores of* CYPAK, Booklet B-6584. Westinghouse Electric Corporation, 5 Gateway Center, P. O. Box 868, Pittsburgh 30, Penna.

WATCH WESTINGHOUSE

WHERE THE FUTURE IS ALREADY IN PRODUCTION!

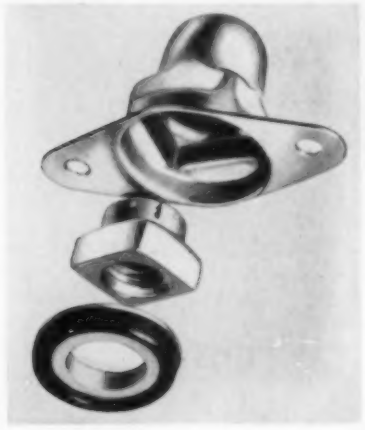
DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 31

NEW SELF-SEALING FASTENERS MADE PRACTICAL BY SILASTIC

There seemingly is no end to the design innovations possible with Dow Corning Silicones. A recent example is the self-sealing dome nut for aircraft developed by Nutt-Shel Co., of Pasadena, California. Containing a ring washer made from Silastic*, Dow Corning's silicone rubber, the new fastener maintains a secure seal despite exposure to operating temperatures ranging from —80 to over 500 F.



Consisting of a retaining shell, self-locking nut and a Silastic-bound ring washer, the assembly is held together in a press fit.

*T.M. REG.U.S.PAT.OFF.

(cont'd pg. 2)

SILICONE FINISH REPLACES PORCELAIN ON COMMERCIAL REFRIGERATOR CABINETS

Already well established as excellent protective coatings for high temperature use, silicone based finishes are now successfully challenging conventional coatings long considered unbeatable for "normal" temperature applications.

Take vitreous enamel or porcelain, for example. A new silicone formulation, Glidden's Nubelon-S, has successfully replaced porcelain on commercial refrigerators produced by the Sherer-Gillett Company of Marshall, Michigan. After using Nubelon-S for two years, Sherer reports that the finish has excellent color retention and that cabinets stay new-looking longer despite abuse from food and beverage stains, abrasive cleaning compounds and shopping cart impacts.

In a test for durability, hammer blows strong enough to dent the metal underneath failed to shatter, crack or chip the silicone based finish. Likewise, the finish on a coated wire shaped into tight coils failed to crack or flake.

Lighter in weight than when coated with porcelain, Sherer-Gillett's silicone finished cabinets are more economical to ship and easier to handle and install. In addition to white, they are available in 5 other sales-stimulating colors.

Sherer-Gillett cabinets are given two coats of Nubelon-S. The flexible silicone coating completely covers all corners and edges, leaving no "black brushing" lines typical of porcelain finishing. Warping is completely eliminated. ***No. 310***

Allis-Chalmers Selects Silicone Insulation for New Transformers

Additional evidence of the superior reliability and economy of silicone (Class H) insulation is the fact that motor and transformer manufacturers — the men who know electrical insulation best —don't hesitate to use it in their own plants.

A case in point concerns several 750 kva silicone insulated dry-type transformers manufactured by the Allis-Chalmers Pittsburgh Works. Three of these units never left the plant. As soon as they were completed, Allis-Chalmers put them on the line supplying power to the plant's six new 360 kva elevator-type electric annealing furnaces.

(cont'd pg. 2)

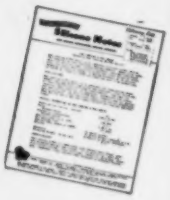
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . .



Documentary film "What's a Silicone?" available free of charge for showings to technical audiences in every industry. In full color and sound, this dramatic 16 mm film allows you to see Dow Corning Silicones in action improving the performance of products ranging from nursing bottle nipples to diesel locomotives. For more information about this educational film and how to arrange a showing for interested persons in your plant, circle *No. 314*

Silicone-Glass Laminates for electrical and mechanical applications are described in new brochure which illustrates parts used in typical industrial applications. Also provides engineering information on silicone-glass laminates and lists fabricators of such laminates. *No. 315*

Dow Corning T-31 glass cloth finish enables producers of structural laminates to meet most specifications with one type of heat-cleaned glass cloth. Effective with epoxy, phenolic, polyester and silicone resins. Easy to apply with conventional equipment, T-31 requires no buffering before application; no washing, neutralizing or curing after application. *No. 316*

"New Developments in Silicone Insulation," an article reprinted from INSULATION magazine, describes several new insulating components and discusses the relative merits of silicone insulation and "modified silicone insulation." Both systems are essentially the same with the exception of magnet wire insulation. Test results indicate both meet Class H requirements. *No. 317*

New solvent resistant, low swell Silastic LS-53, a fluoro-silicone rubber, has excellent resistance to gasoline, aromatic solvents, jet fuels and high aromatic oils. Developed by Dow Corning in cooperation with Wright Air Development Center, this new rubber should have a wide range of applications in aircraft, chemical, petroleum and automobile industries. Presently limited to use in essential Air Force applications, but increased production is expected soon. Preliminary data sheet now available. *No. 318*

BEARINGS IN KITCHEN RANGE DOORS LUBRICATED WITH SILICONE FLUID

Stimulated by competition for the billion dollar home appliance market, more and more manufacturers are creating "exclusive" selling features by using Dow Corning Silicones to increase eye-appeal and performance. Take the 40-inch Kelvinator range, for example.

This all-modern kitchen range features oven doors that function smooth as silk for the life of the range. Easy operation is achieved by mounting the doors on ball bearing bushings. To obtain an extra measure of dependability, the bearings are lubricated with Dow Corning 710 Fluid.

A standard specification since the range was introduced six years ago, the silicone oil provides long term lubricity despite oven temperatures to 500 F, a job no organic lubricant could do. The oil is applied by simply immersing the bearings in 710 Fluid and allowing them to drain.

Exceptional heat stability and oxidation resistance are two reasons why Dow Corning 710 Fluid provides adequate long time lubrication at temperatures from zero to 500 F. Indicative of its stability is a volatility of only 2 per cent after 12 months at 300 F and a gel time of 1500 to 2000 hours at 500 F. *No. 311*

SELF-SEALING FASTENERS *(cont'd)*

To eliminate possible pinching and subsequent cold flow, the Silastic ring seal is designed to retract into the shell when the nut is attached. When the nut and bolt are in place, the Silastic forms a seal that is unaffected by successive bolt installations.

The Silastic ring maintains a secure seal despite exposure to hot air, ammonia, synthetic oils and gasoline. It has an operating pressure range ± 50 psi and exceeds temperature requirements for aircraft fuel Types 1, 2 and 3 of MIL-R-6855.

Because no sealing compounds are required, installation and maintenance of the fasteners is fast and easy. In fact, the units have proven so successful and economical in use, they are currently specified by eleven leading airframe manufacturers.

Here is another example proving that it pays to consider Silastic for diaphragms, gaskets, seals and other parts that must give reliable service and retain rubber-like properties at any temperature from —130 to over 500 F. *No. 312*

SILICONE INSULATED TRANSFORMERS *(cont'd)*

The furnaces are designed to heat-treat transformer core steel to over 2000 F in a controlled atmosphere of hydrogen.

Asked why silicone insulation was specified, the engineer in charge of the installation said, **"With Class H, you install them and forget them."** *No. 313*

Dow Corning Corporation, Dept. 8610, Midland, Michigan

Please send me: 310 311 312 313 314 315 316 317 318

NAME _____

TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

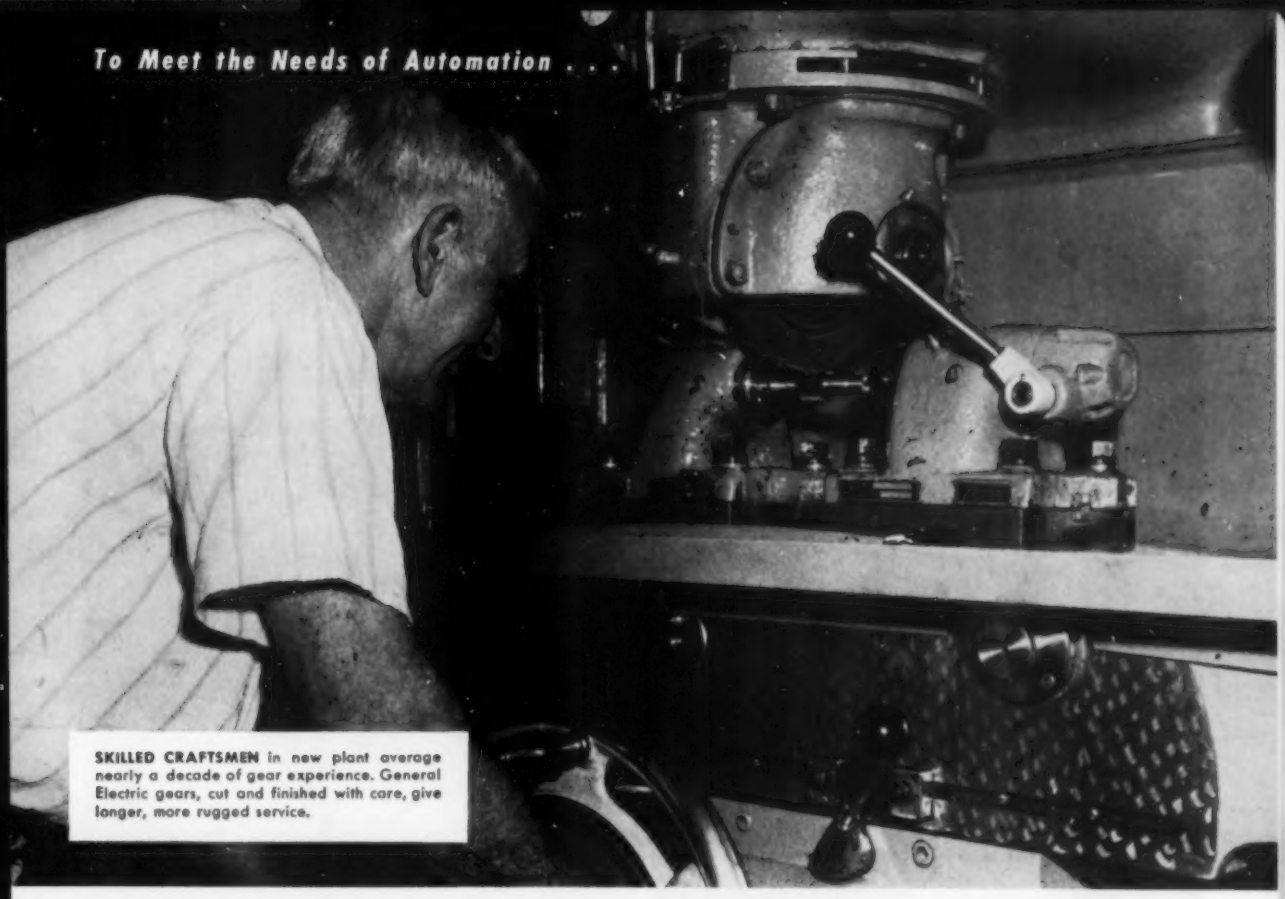
SILICONE NEWS is published for product design and development engineers by

DOW CORNING CORPORATION
MIDLAND MICHIGAN

first in silicones
DOW CORNING SILICONES

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS DETROIT LOS ANGELES NEW YORK WASHINGTON, D.C. (SILVER SPRING, MD.)
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

To Meet the Needs of Automation . . .



SKILLED CRAFTSMEN in new plant average nearly a decade of gear experience. General Electric gears, cut and finished with care, give longer, more rugged service.

At General Electric's NEW Gear Motor and Transmission Components Department . . .

3618 man-years of manufacturing know-how assure fast service on low-speed drives

To meet the increased demand for low-speed drives, General Electric's new decentralized Gear Motor and Transmission Components Department will be devoted solely to the design and manufacture of mechanical power transmissions.

•**Specialized Attention**—Highly trained and experienced gear-motor engineers and skilled craftsmen with over 3600 man-years of experience are available to help solve your low-speed drive problems. They are ready to give you fast, dependable G-E service on standards, on specials, and on new gear-motor products.

•**Complete Line Available**—General Electric offers a complete line of gear-motors—induction, synchronous, wound rotor, d-c gear-motors—in all types and enclosures, from 1/100 to 200 hp. The new department will also give you rapid service on special needs such as adjustable speed, braking, special mounting or special insulation.

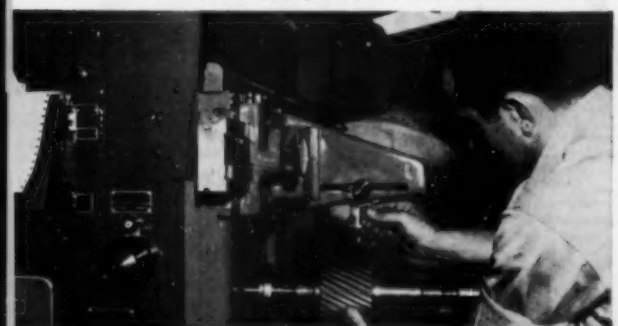
•**Fast Service**—The expanded gear-motor facilities allow quantity production and shorter manufacturing cycles. Machine tools in the new factory are designed for high volume precision work and are readily adaptable for the production of specials built to your specifications.

•**For More Information**—Write for bulletin GEA-6027, Section 851-2, Schenectady, N. Y., or contact your G-E Apparatus Sales Office or gear-motor supplier. Gear Motor and Transmission Components Department, General Electric Co., Paterson, N. J.

Progress Is Our Most Important Product

GENERAL ELECTRIC

CONTINUOUS TESTING provides data for quality control, new designs and developments. Here, an involute measuring instrument records wear, under simulated tortuous conditions, to nearest ten-thousandths of an inch.



QUANTITY PRODUCTION of complete line of G-E gear-motors from 1/100 to 200 hp, in all types and enclosures, assures prompt customer service. Specify General Electric for all your low-speed drive needs.

Designing parts from *Carpenter* Stainless No. 20 helps tame corrosive rocket fuels

Internal parts of "flow sensing" units which control the flow of fuel to rocket engines, must combine super corrosion resistance and mechanical durability. They meter liquid oxygen at —297°F and a 90-98% concentration of red fuming nitric acid. That's why these critical parts were designed with the super corrosion resistance of Carpenter Stainless No. 20, and machined from No. 20 bar stock.

The units measure fuel flow accurately to within $\frac{1}{10}$ of 1%. Yet they are so durable that when rocket experts dig wrecked missiles out of desert sands they recover the units for re-use.

When you design parts, components or complete pieces of equipment for handling sulphuric acid or other strong corrodents, consider the economy of designing with this super corrosion-resisting stainless.

Call your nearest Carpenter Mill-Branch Warehouse, Office or Distributor . . . or write direct for full information on the cost-saving advantages of Carpenter Stainless No. 20.

Carpenter Stainless No. 20-Cb is available from The Carpenter Steel Company, Alloy Tube Division, Union, New Jersey, in the forms of tubing, sheet, strip, pipe and plate; and Stainless No. 20 in the forms of bars, billets and wire.

Carpenter STEEL

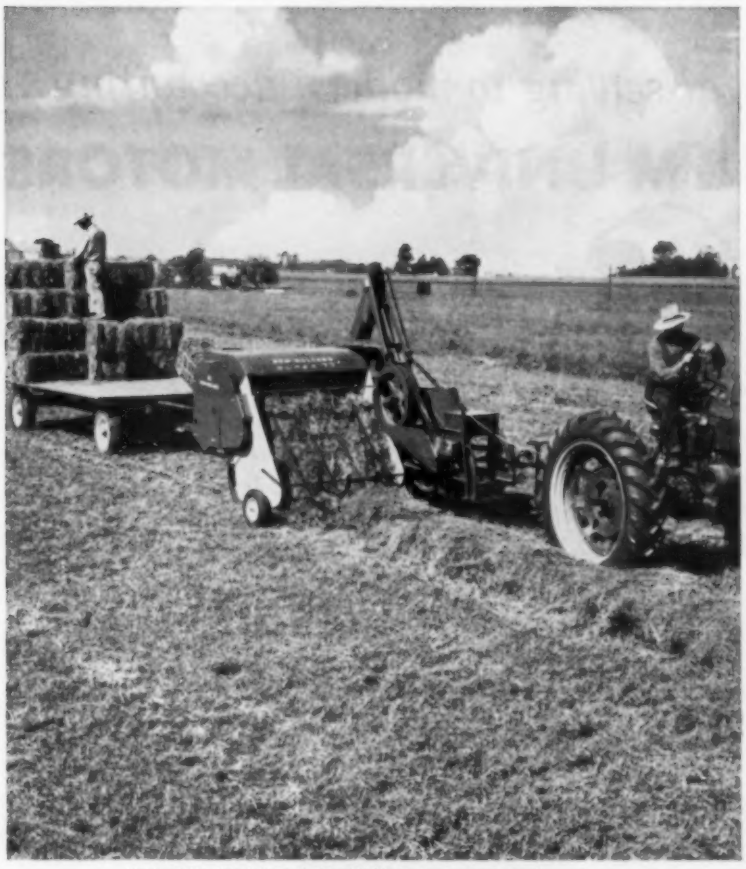
Super Corrosion-Resistant Stainless

Pioneering in Improved Tool, Alloy and Stainless Steels through Continuing Research

The Carpenter Steel Company, 117 W. Bern St., Reading, Pa.

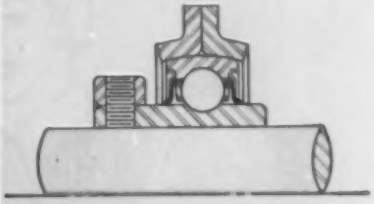
Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

MORE FACTS on why more and more leading manufacturers choose Link-Belt bearings

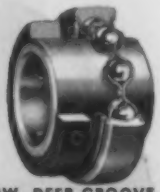


THIS NEW HOLLAND HAY BALER is typical of equipment on which JPS-200 ball bearing pillow blocks are popularly applied.

SELF-ALIGNING. Free-rolling and full load capacity of the JPS-200 ball bearing pillow block are maintained even with shaft deflection or misalignment.



MAXIMUM SEALING EFFICIENCY. Synthetic rubber lip-type seal, integral with bearing, keeps lubricant in, dirt out. Greased at factory ready for operation.



SINGLE-ROW, DEEP-GROOVE standard Series 200 ball bearing is used. Extra-long inner ring assures proper load distribution—heavy spring locking collar firmly secures bearing on shaft.

√Low cost √Compactness √Self-alignment

Link-Belt JPS-200 ball bearings combine all three

HERE is a new concept in bearing design—a proven answer to the economy needs of many equipment manufacturers. And most important—this JPS-200 Series ball bearing pillow block achieves low cost without sacrifices in bearing design.

The standard, full-capacity, self-aligning Series 200 ball bearing is supported in a rugged, pressed steel housing. Further economies result because the JPS-200 arrives in *one piece*—ready for fast, foolproof installation. And standard dimensions plus extreme compactness are added aids to the designer.

Ask any one of 40 Link-Belt offices for Folder 2517 containing complete information on the JPS Series. And get Book 2550 for data on Link-Belt's complete ball and roller bearing line.

LINK-BELT

Ball and Roller Bearings

Rugged, steel-clad JPS-200 Series — from industry's most complete line of ball and roller bearing pillow blocks.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,088-A

from industrial sewing to modern accounting...

RUGGED R & M UNIVERSAL MOTORS

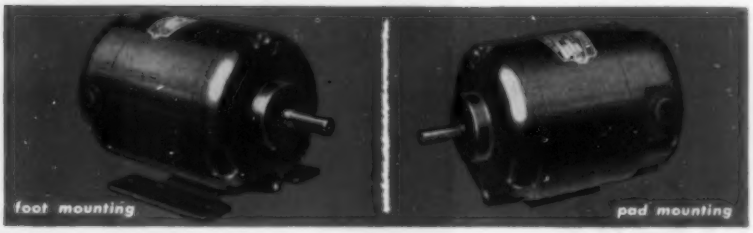
available in sizes
from 1/50 to 1/2 horsepower

PROVIDE DEPENDABLE PERFORMANCE!

VERSATILE R & M Universal Motors are engineered to provide the best power component possible for your product, capable of years of trouble-free performance. Note these outstanding features of R & M Universal motors: pad base, foot base or end mountings permit versatility in the design of your product; cast iron heads have clean appearance, excellent accuracy; double shielded ball bearings keep grease in, dirt out; armatures are dynamically balanced for quiet, vibrationless operation; sturdy commutators and brush holders are selected with infinite care.

Standard R & M Universal motors are available in ratings from 1/50 to 1/2 h.p. Other ratings are available through custom design to your specific applications!

Write for Bulletin 444 PE and name of your R & M representative.



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ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

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GOOD AND STRAIGHT—*won't whip!*

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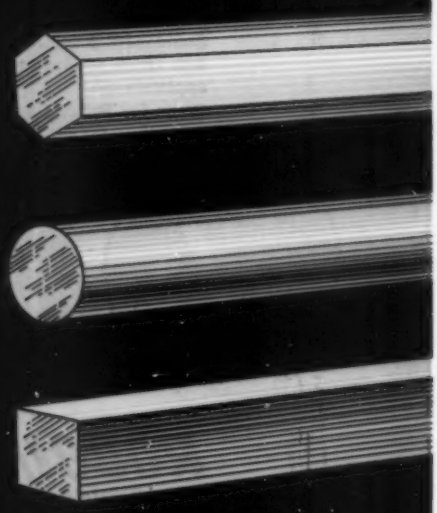
ROD · BAR · SHAPES

Screw machines really purr along when you feed them Chase Free-Cutting Brass rod! Uniform lengths and straight lengths that won't whip, superior machinability, longer runs before regrinding tools, all mean more pieces per length, fewer rejects and less down time per machine. Order from your Chase warehouse!



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Atlanta Baltimore Boston Charlotte Chicago Cincinnati Cleveland Dallas Denver Detroit Grand Rapids Houston Indianapolis Kansas City, Mo. Los Angeles Milwaukee Minneapolis Newark New Orleans New York Philadelphia Pittsburgh Providence Rochester St. Louis San Francisco Seattle Waterbury

Drafting Department Heads! Now Is the Time to Gear Your Department to Meet Growing Production Demands!

NOW Is the Time to Get Your New, Modern Bruning Copyflex Machine!

Copyflex Model 500—Top mechanical speed of 40 f.p.m., front or rear delivery, automatic separation and stacking, many other features.

The boom in production means more pressure than ever for engineering drawings and prints. Right now is the time to replace that old inadequate reproduction machine you've been putting up with—now's the time to get a modern, efficient Bruning Copyflex.

In just the last year, Bruning has introduced five new, advanced machine models, one of which is shown at the left. These machines offer you the famous problem-free operation of Copyflex . . . no exhaust venting, no plumbing or auxiliary equipment, no installation other than an electrical connection. They bring you faster reproduction speed and a host of operator conveniences such as fast return of originals, automatic separation, front or rear delivery. They are the efficient, economical, modern reproduction machines that will help you boost your drafting room output, keep costs at a minimum.

Now is the time to act. Mail the coupon below. You'll be glad you did!

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Please send me information on Copyflex process and Model 500 machine.

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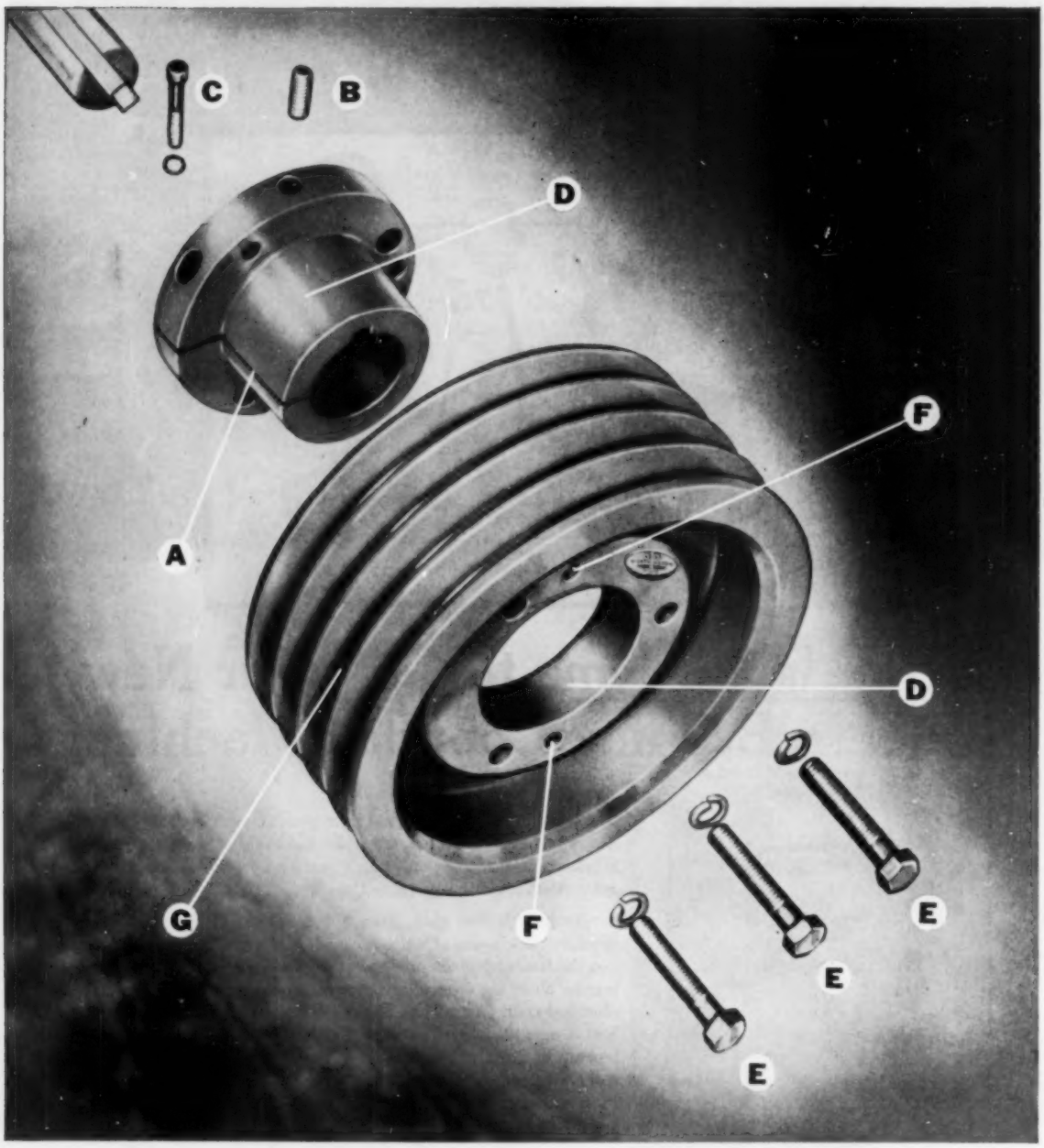
Again in '55, industry's



Exclusive design. All Worthington QD sheaves have these outstanding product features:

A- Completely split QD hub holds shaft tightly under heaviest shock loads.

B- Cup point set screw* in QD hub keeps shaft key in position.

C- Clamp screw* secures hub in proper alignment on shaft when mounting sheave.

D- Tapered fit between hub and sheave allows easy-on, easy-off, hold-tight action.

E- Pull-up bolts draw sheave on to hub to produce positive fit on shaft.

F- Tapped holes in sheave permit pull-up bolts to be used as jack screws to break cone grip when removing sheave.

G- Groove cross-sections are accurate and uniform so that each V-belt seats properly, pulls evenly.

**All Worthington-manufactured QD heavy duty hubs incorporate these exclusive features*

best selling sheave

9 outstanding features make Worthington QD the favorite of design engineers

According to authoritative industry figures, more QD sheaves were sold last year than any other type. Design engineers tell us they prefer the QD—the original two-piece design—because of these 9 outstanding features:

1 EXCLUSIVE DESIGN. As shown at left, Worthington QD sheaves have many outstanding product features which mean real benefits to all users.

2 EASY TO INSTALL AND REMOVE, the QD's tapered hub slides on shaft, locks with a cap screw for permanent alignment. Sheave slides on hub and pulls up with three big bolts for tight holding. Comes off just as easily.

3 BALANCED PERFORMANCE of Worthington Multi-V-Drives, due to accurate uniform grooves and precise mating (with Worthington-Goodyear V-belts), gives you even tension, even pull, even speed, even wear, less vibration.

4 SMART APPEARANCE. The QD sheave's scientific design not only provides more efficient transmission of power but actually adds to the looks of your product.

5 QUICK DEPENDABLE SERVICE—factory-warehouses back distributors.

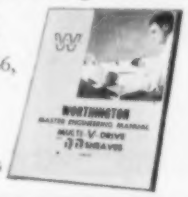
6 MATCHES YOUR QUALITY STANDARDS. QD sheave quality stems from extremely accurate balance, tough close-grained semi-steel metal, rigid inspection for minimum tolerances, and "I-beam" arm construction of driven sheaves which gives greater strength with less weight.

7 WIDE RANGE OF SIZES with factory-warehouse stocks covering over 100,000 V-belt drive combinations from ½ to 600 hp.

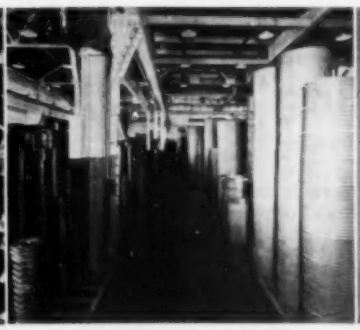
8 WIDE RANGE OF APPLICATIONS. QD sheaves have been job-tested and accepted on every class of equipment and in every industry. Some of the many applications in which QD sheaves have given outstanding performances include: blowers, boring mills, compressors, conveyors, crushers, elevators, grinders, lathes, stokers, oil field machinery and many, many others.

9 COMPLETE ENGINEERING DATA—yours for the asking. In Worthington's 100-page manual, tabbed, easy-to-find tables enable you to select the right sheave and V-belt combination for any job in only three minutes. For your free copy write to Section MV66, Worthington Corporation, Oil City, Pa. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ont.

MV.6.6



Over 400 stock Worthington-Goodyear V-belt sizes.



Over 100,000 drive combinations available from warehouse stocks.

13 factory-warehouses back more than 250 distributors.

WORTHINGTON

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

Compressors • Pumps • Multi-V-Drives • Variable Speed Drives

See what adhesives are doing today!

THIS 3M SEALER PERFORMS SO DEPENDABLY, DOUGLAS AIRCRAFT FINISHES CABINS ENTIRELY BEFORE PRESSURE TESTING.

Pressure sealing for 20,000 hours plus

In a large number of Douglas aircraft, this 3M pressure cabin sealer already has logged more than 20,000 hours without sign of failing. So far, there's *no known limit* to the endurance that its users can expect.

When 3M developed the first successful pressure cabin sealer in 1946, government specifications were written around it. Since then, 3M sealer has been used on more aircraft, logged more hours by far, than any other brand of pressure cabin sealer.

Available as a light or dark colored semi-liquid, this 3M sealer can be applied quickly and easily. It conforms to contours, fills voids, bridges gaps, cures quickly into a flexible solid. Airborne, it stays flexible, adheres tightly despite flight stresses, high altitude cold, desert heat and exposure to water, gasoline and oil.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

Pressure cabin sealing is only one of the many problems 3M research is helping the aircraft industry solve. A special staff of experienced 3M experts stands ready to assist you. Consult your 3M Aircraft Field Engineer. Or for further information and literature write: 3M, Dept. 410, 6411 Randolph Street, Los Angeles 54, California.

PRODUCT OF 3M RESEARCH

3M ADHESIVES

ADHESIVES AND COATINGS DIVISION, **MINNESOTA MINING AND MANUFACTURING COMPANY**

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MAKERS OF "SCOTCH" BRAND PRESSURE-SENSITIVE TAPES • "SCOTCH" BRAND SOUND-RECORDING TAPE • "SCOTCHLITE" BRAND REFLECTIVE SHEETINGS • "3M" ABRASIVE PAPER AND CLOTH • "3M" ADHESIVES AND COATINGS • "3M" ROOFING GRANULES • "3M" CHEMICALS

Bob Rossi, Chief Engineer, tells
Roy Johnson, Plant Manager

"We switched to Formbrite —and saved 12 cents apiece!"

.032" gage 70-30 Formbrite is used for this 4½" diameter rearview mirror head shown full size. Strip is 5$^{13}/_{32}$" wide supplied in heavy coils for long press runs. Copper, nickel and chromium plating on a solid brass base provides a bright, rustless, long-lasting outdoor finish.

Peerless Rearview Mirrors. "Flight-Wing," below, and the newer "Director" model, left. Housings and mounts are chromium-plated zinc-base die castings.

This easy-to-polish, superfine-grain drawing brass has been slashing finishing costs in plant after plant, on all kinds of jobs. Now Peerless Accessories Co., of Mount Holly, N. J., reports:

"To our line of lighting and safety automotive accessories, we've recently added two rearview mirror assemblies. We had been using regular drawing brass for the dished head until your representative persuaded us to try Formbrite. Here are the results, based on a very careful cost study:

Finishing procedure using regular drawing brass	Present procedure using Formbrite®
1) Grease grinding or "cutting"	Not necessary with Formbrite
2) Buffing	Light buff
3) Copper strike	Copper strike
4) Nickel plate (.00045")	Bright nickel plate (.0003")*
5) Buffing nickel	Not necessary
6) Chromium plate	Chromium plate
Cost 27¢ each	**Cost 15¢ each**

"That's a saving of 12 cents apiece. Multiply it by 3,000 to 4,000 a day and it becomes important money!"

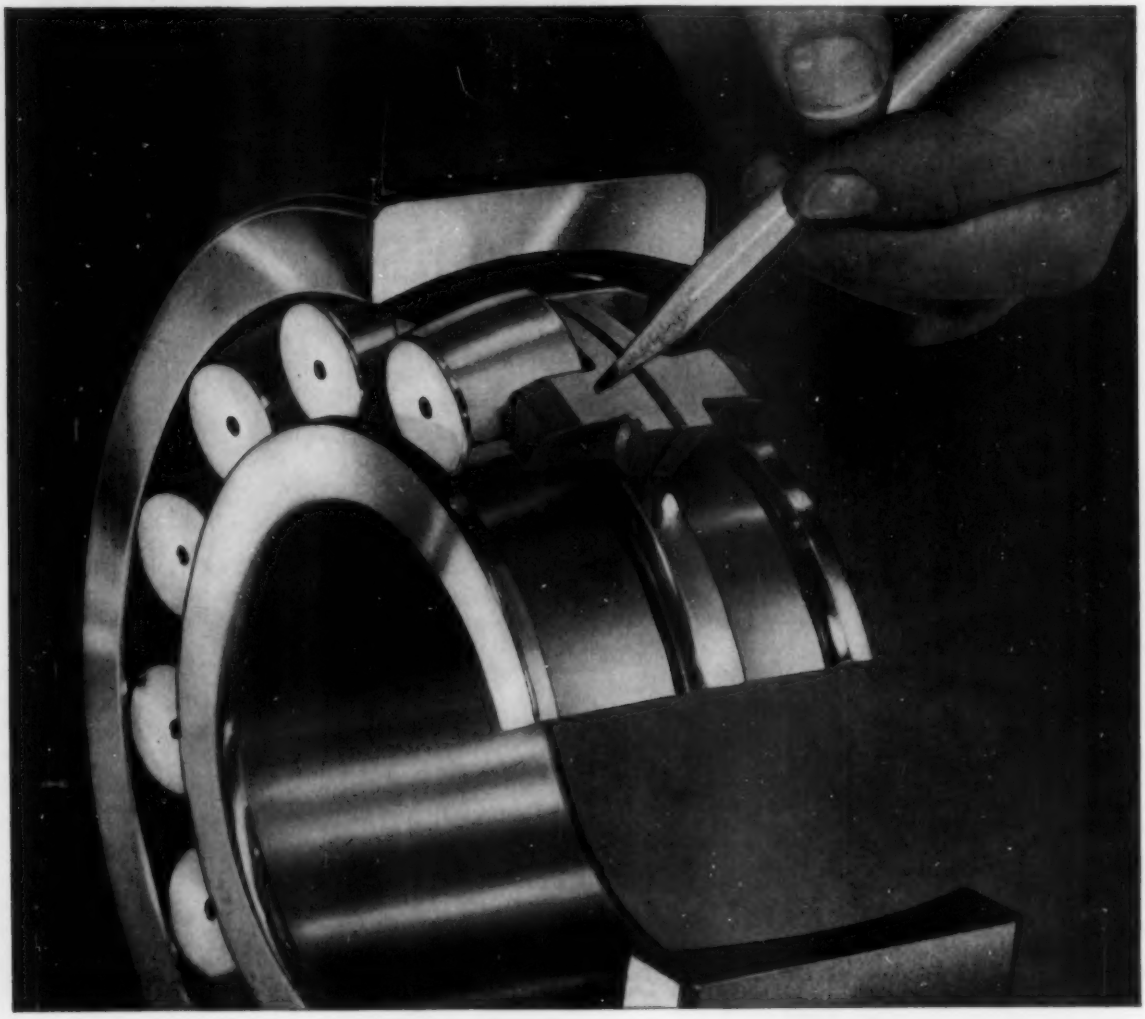
*Formbrite's superfine grain made possible a lighter but equally serviceable plate of *bright* nickel

Surprisingly, Formbrite doesn't cost a penny more. Find out for yourself how its superfine grain, excellent drawing properties, strength, and scratch resistance can help you make a better product at lower cost. Write for Publication B-39. Better yet, ask us about a sample lot. The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 5670

Formbrite FINE-GRAIN DRAWING BRASS

an ANACONDA® product
made by The American Brass Company

TORRINGTON *SPHERICAL ROLLER* BEARINGS



Land-riding cages for longer life!

These fully machined cast-bronze, land-riding cages—one for each path of rollers—are important performance builders in TORRINGTON'S Spherical Roller Bearings. The one-piece retainers keep the rollers perfectly aligned at all times, even under conditions of shock load and sustained speeds. Lubrication is more effective, too, as the lubricant has easy access to vital points of contact between rollers and races.

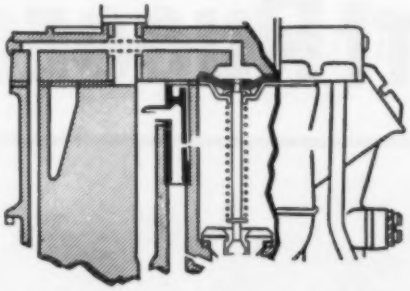
This feature is typical of TORRINGTON'S design, made possible through long experience in serving industry with the finest in precision bearings. That's why it pays to look to TORRINGTON first when your application calls for Spherical Roller Bearings. They're available from stock with either straight or tapered bore, for shaft or adapter mounting.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

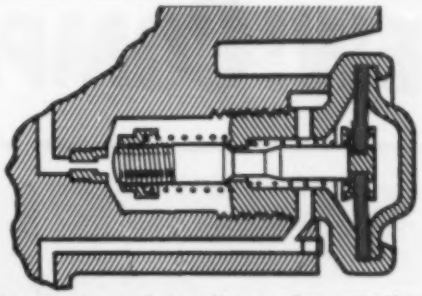
90th ANNIVERSARY 1866–1956

TORRINGTON BEARINGS

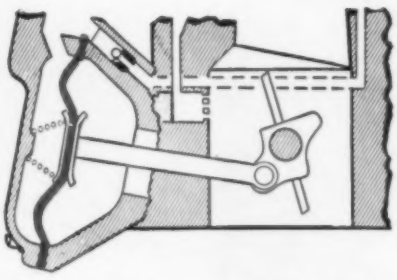
Spherical Roller • Tapered Roller • Cylindrical Roller Needle • Ball • Needle Rollers



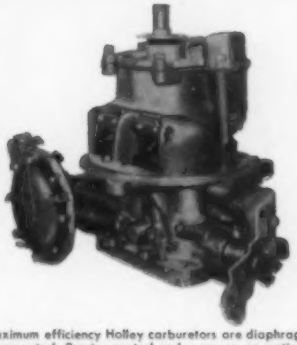
Economizer diaphragm (shown in red) functions automatically to control the correct amount of fuel for the fuel-air mixture. Du Pont "Fairprene" diaphragm resists aging—remains sensitive even in the presence of gasoline vapors at engine operating temperatures.



The acceleration pump diaphragm (shown in red) prevents backfiring or slowdown during sudden acceleration. Diaphragm must withstand severe flexing in the presence of gasoline vapor. "Fairprene" withstands this service with no flex cracking or deterioration.



Secondary throttle diaphragm (shown in red) regulates fuel on the four-barrel carburetor. This diaphragm must be sensitive and resist permanent set and drift. Dependable performance of Du Pont "Fairprene" helps explain the successful operation of the Holley carburetor.



For maximum efficiency Holley carburetors are diaphragm- rather than piston-operated. Precise control under severe operating conditions is assured by use of diaphragms of Du Pont "Fairprene."

Designers at Holley Carburetor Co. find...

Diaphragms of Du Pont "Fairprene"® assure lasting resistance to fuel and flex cracking

DU PONT INDUSTRIAL COATED FABRICS

COATING MEDIUMS

Neoprene • Buna-N • Silicone • Polyacrylate
Chlorosulfonated Polyethylene • Tetrafluoroethylene
Butyl • Acrylic • Polyamide
Polyethylene • Polysulfide

SUBSTRATES

Fabrics	Felts or Non-Woven
Cotton . Nylon . "Dacron"*	"Teflon" Felts
"Orlon"** . Asbestos . Glass	Wool Felts
Metal . Rayon . "Teflon"***	

Also elastomer sheet stocks without fabric inserts and cements

*"Dacron" is Du Pont's registered trademark for its polyester fiber
**"Orlon" is Du Pont's registered trademark for its acrylic fiber
***"Teflon" is Du Pont's trademark for its tetrafluoroethylene fiber

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

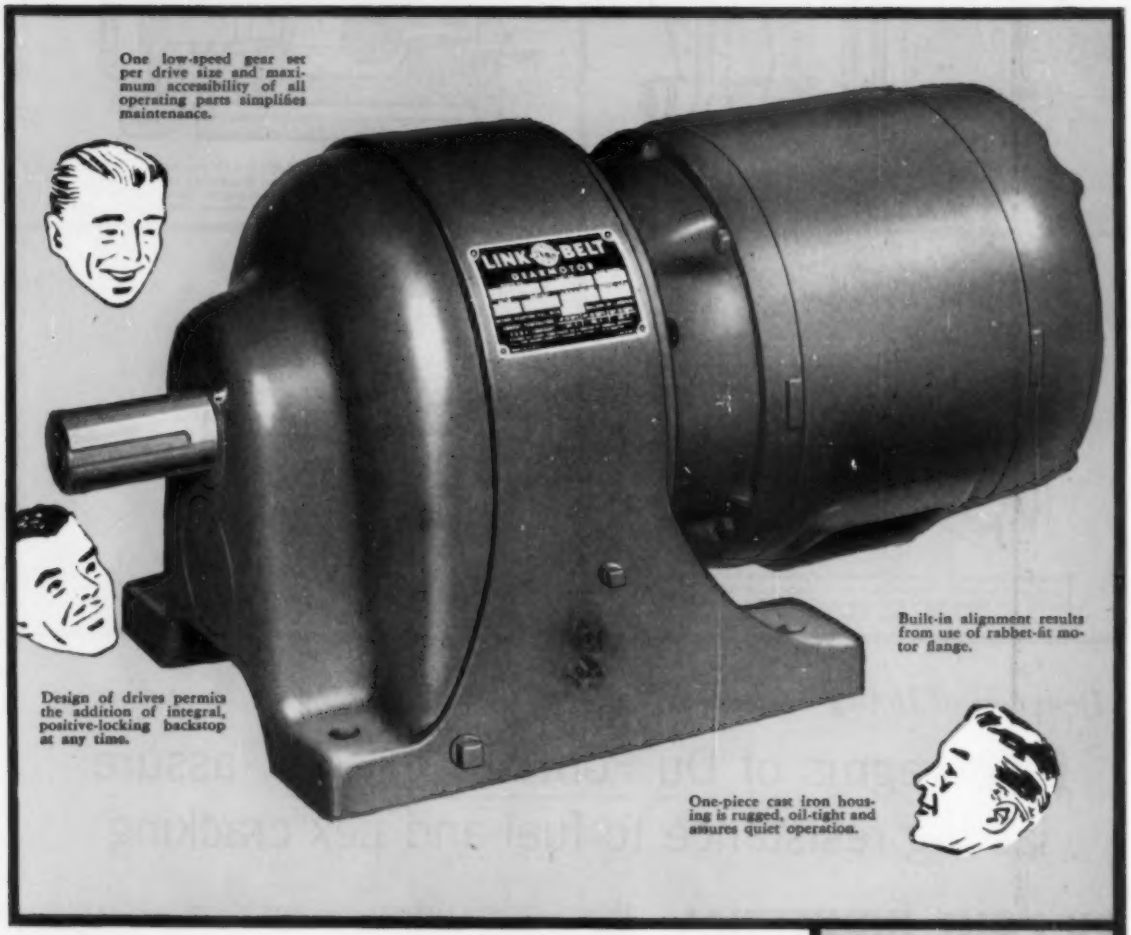
Holley Carburetor Company must have reliable performance from their diaphragm-operated carburetors. That's why they specified Du Pont "Fairprene" coated fabrics for the diaphragm parts. Holley requirements for diaphragms of "Fairprene" were sensitivity, resistance to gasoline and fuel additives, flex resistance and long life. Du Pont "Fairprene" proved to be just right for the job.

This is just one application in which Du Pont "Fairprene" has proved its effectiveness. Used in diaphragms, gaskets, washers, packings, insulating pads, sealing tape or tarpaulins, "Fairprene" shows exceptional resistance to deterioration. Oils, greases, solvents, chemicals, abrasion and flexing in extremes of temperatures from -60°F. to 200°F. do not affect its performance or reduce its long life. It may pay you to investigate possible uses of Du Pont "Fairprene" coated fabrics in your product. For more information and technical data on uses of Du Pont "Fairprene" fill out and mail the coupon. It's free—mail the coupon today.

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division, Dept. PE-610 Wilmington 98, Delaware
Please send me your bulletin on technical data and uses of Du Pont "Fairprene" coated fabrics.

Name _____ Position _____
Company _____
Address _____
City _____ State _____

NEW! COMPACT! RUGGED!


One low-speed gear set per drive size and maximum accessibility of all operating parts simplifies maintenance.
LINK-BELT
GEARMOTOR
Built-in alignment results from use of rabbet-fit motor flange.
Design of drives permits the addition of integral, positive-locking backstop at any time.
One-piece cast iron housing is rugged, oil-tight and assures quiet operation.

LINK-BELT GEARMOTORS

maintain positive alignment with flange-mounted NEMA motors . . .

Dependable alignment, long-lasting efficiency and quiet, oil-tight operation — every quality that constitutes top drive performance is built into modern Link-Belt Gearmotors. New design concepts with improved construction and latest manufacturing methods provide maximum economy, minimum maintenance in heavy-duty service.

Choose a Link-Belt Gearmotor up to 30hp, speeds from 280 down to 6 rpm. Contact your nearest Link-Belt office or authorized stock-carrying distributor today.

Ask for new 28-page Book 2447—offering interesting design highlights and complete engineering data.

LINK-BELT

ENCLOSED DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 12,909

Link-Belt has also developed a new line of Motogears for bracket-mounting NEMA foot-type motors of any manufacture, with such outstanding features as quick motor replacement, straddle-mounted pinion and other advantages essential to continuous service under shock, reversing and heavy loads.

How to Control Heat in a Large Oven

No. 4 of a series — *Showing the Broad Application Range of Fenwal Controls*

The oven is designed to dry 30 yards of finished goods per minute at oven temperatures up to 400°F. The problem was to maintain the desired 330°F in the oven. Here's how this was accomplished —

The many electric heaters, which are distributed uniformly in the oven, provide a total heat input of about 60,000 watts and are divided into two separate control circuits. About one-third of the heaters are controlled by a simple on-off controller of moderate sensitivity to maintain a basic heat level in the oven. The remaining heaters are operated by the Fenwal Series 560 Portable Temperature Indicating Controller, an instrument of high sensitivity and rugged construction. The Series 560 provides the proportioned heat necessary for accurate control of the curing process. It also can be used for straight on-off control. Here's the way the control set-up works —

To maintain the desired 330°F in the oven, the on-off controller is set at 315°F, while the proportioning controller is set at 330°F. So both heater circuits are on during oven warm-up or when incoming fabric depresses the oven temperature below 315°F. Above 315°F, the on-off controller shuts off the heaters in its circuit, and the process heat is obtained from the remaining heaters under the control of the Fenwal Series 560 Controller.

Integrated Sensitivity a Big Advantage in The Series 560

In the Fenwal Series 560 Temperature Indicating Controller the superior thermoelectric qualities of the revolutionary thermistor are used to fullest advantage. The great resistance change of the thermistor in response to temperature change results in extreme sensitivity. It also enables the use of a simple null balance bridge circuit for increased stability. And it permits the use of a standard electric conductor as a connecting wire — *no special wire is required.*

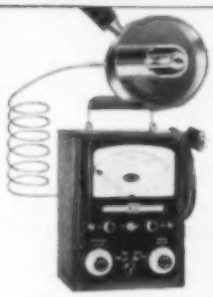
These characteristics have been *integrated* by Fenwal into a rugged, durable instrument which is the first to combine all three major modes of indicating control — on-off, proportional and adjustable differential — *all functioning with high sensitivity at the flip of a switch.*

THIS 600 CUBIC FOOT CURING OVEN, planned and installed by Atlas Textile Machinery Co., Paterson, N. J. at the Gsell Textile Printing Corp. plant in New York, uses the Fenwal Series 560 Portable Temperature Indicating Controller to provide uniform drying conditions within 2 degrees of the set point.

Proved Applications

Fenwal Sales Representatives and Engineers have saved time, trouble and money in all types of plants and laboratories by solving thousands of temperature control and detection problems. Fenwal THERMOSWITCH® units are controlling processes that involve liquids, gases and solids.

Put Fenwal's vast reservoir of technical know-how to work for you. Chances are your problem has already been met and mastered by Fenwal engineers. Write for Catalog No. 500 for complete information.



SERIES 560 INDICATOR CONTROLLER with magnified cutaway view of thermistor probe.

FENWAL INCORPORATED
210 Pleasant Street
Ashland, Mass.

Please send me your Catalog No. 500. Our specific problem is:.....

.....

.....

Name.....*Title*.....

Address.....

City.....*Zone*...*State*.....

Fenwal CONTROLS TEMPERATURE . . . *PRECISELY*

Hinged Arm *prevents* Contact Troubles in MALLORY Rheostats

ONE OF THE IMPORTANT REASONS why Mallory Power Rheostats give superior performance is their unique hinged contact arm. Exclusive with Mallory, this construction assures correct pressure at all times, between the brush and the winding. You can lift the arm to clean or replace the brush . . . and the spring snaps back to exactly the right pressure. *The spring carries no current* . . . won't anneal and lose its tension during overloads.

Other notable design features are built into these rheostats. Ceramic insulation for current-carrying members is selected for high dimensional stability. Tough, impervious vitreous enamel protects the winding. Overall design assures good ventilation and cool operation at full ratings.

Precise linearity is obtained through Mallory-developed winding techniques. Special tapers can be produced with a *single* wire by means of Mallory variable pitch winding, which eliminates hot spots and points subject to breakage.

Standard Mallory rheostats cover the full range of most industrial applications . . . with ratings of 25, 50, 75, 100, 150, 225, 300 and 500 watts. In addition, we will be glad to engineer special single, dual or multiple units for your particular needs. Write to Mallory today for our Technical Bulletin describing all Mallory wire wound resistors and rheostats.

Parts distributors in all major cities stock Mallory standard components for your convenience.

Expect more . . . Get more from

Serving Industry with These Products:

Electromechanical—Resistors • Switches • Television Tuners • Vibrators
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Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

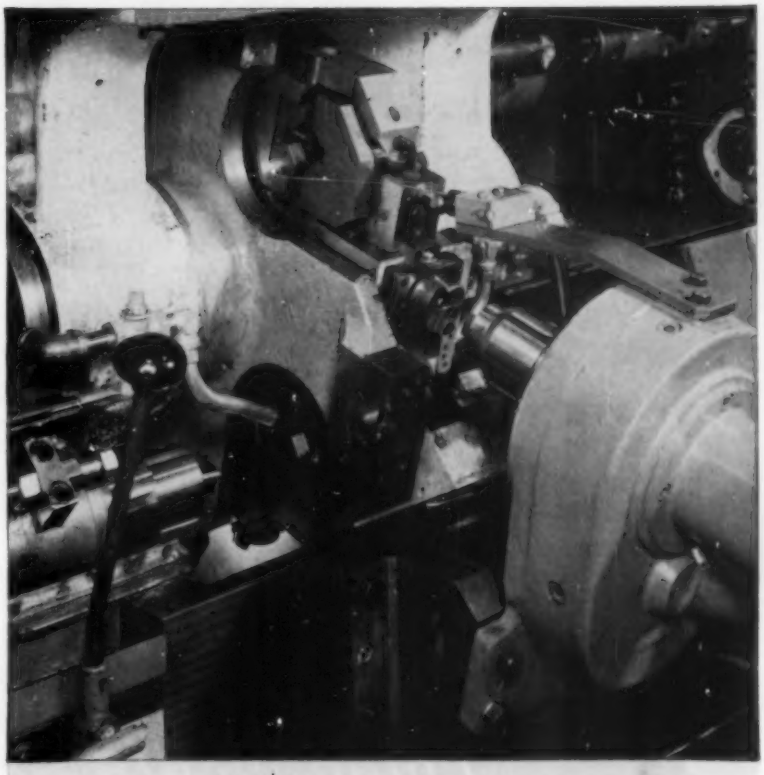
More precision — no more backlash after turret was mounted on TIMKEN® bearings

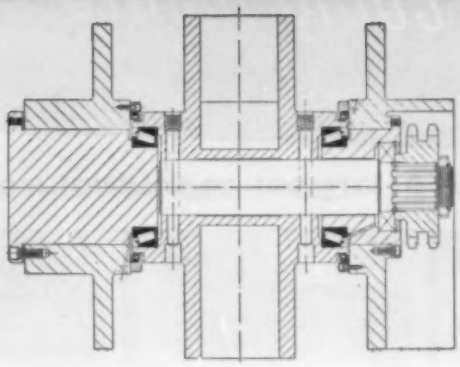
50 Timken® bearings are used in this Model 365 New Britain chucking machine, which can machine both ends of suitable castings or forgings simultaneously. The turret spindle of this machine was originally mounted on a plain bushing. This method did not eliminate backlash completely. When Timken tapered roller bearings were mounted at each end of the turret shaft, backlash was eliminated altogether, rejects cut. Timken bearings also prevent chatter and insure precision because they can be preloaded to any degree necessary to maintain the required rigidity.

Timken bearings can handle heavy loads because they carry them on the lines of contact between rollers and races. Their tapered construction permits them to take radial and thrust loads in any combination. Geometrically designed for true rolling motion and precision manufactured to live up to their design, Timken bearings practically eliminate friction.

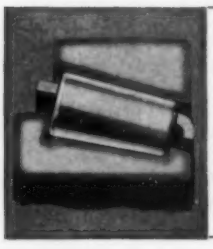
We even make our own special analysis steel to be sure Timken bearings are the best. We're the only U. S. bearing maker that does. When you buy or build machines, always specify Timken bearings. Look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.





How **THE NEW BRITAIN MACHINE COMPANY** mounts the turret of its Model 365 Double-End Automatic Chucking Machine on Timken bearings to improve precision, minimize maintenance.



GREATER LOAD AREA

Because the load is carried on the *line* of contact between rollers and races, Timken bearings carry greater loads, hold shafts in line, wear longer. The Timken Roller Bearing Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis Timken steels.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ▯ AND THRUST →▯← LOADS OR ANY COMBINATION ✳

INVENTORY OF MORE THAN 3000 glass formulas has been developed and tested by A. O. Smith research in a continuing program that began in 1928. All this for the sake of protecting the world's most useful metal — steel — extending its life and performance abilities.

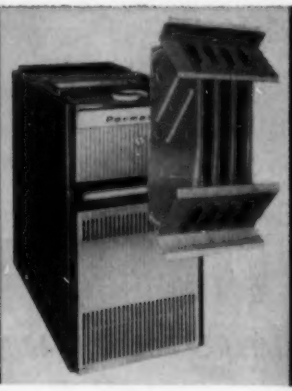
SHRUGS OFF CORROSIVE ATTACK. Photo shows two rods of steel immersed in a sulphuric acid bath. Oxidation occurs immediately to the unprotected steel rod on the left ... while the rod at right, with its sure-blue coat of A. O. Smith acid-alkali glass, remains unaffected.

Remarkable glass -

could insure the future of

World's largest manufacturer of glass-protected

PERMAGLAS water heaters ... set new standards of life expectancy in tank linings.



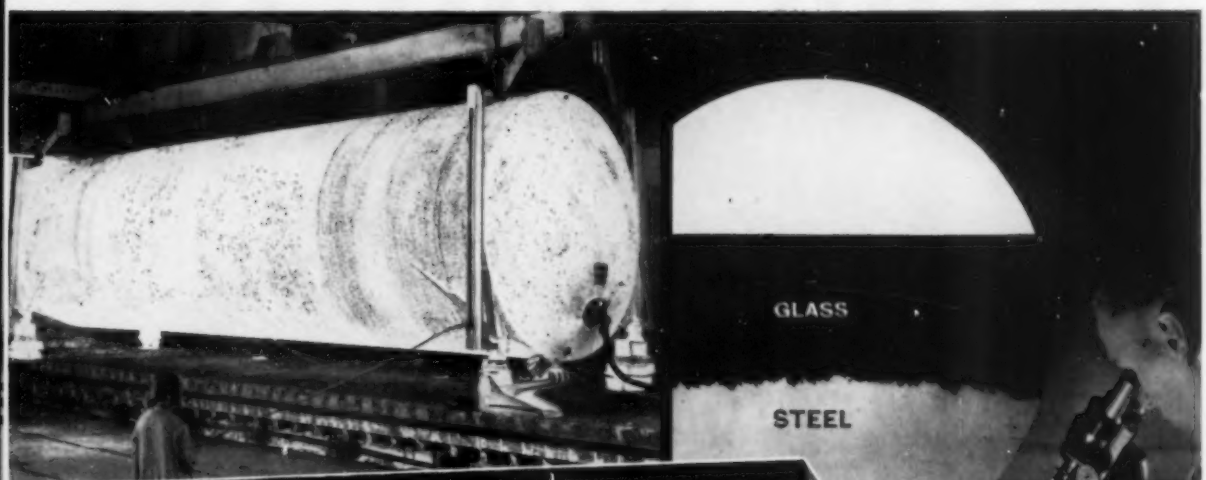
PERMAGLAS home heating and cooling ... ceramic-coated heat exchangers prevent oxidation and condensate corrosion.

HARVESTORES for farm feed processing ... *Permaglas* mechanized storage structures, handling industrial bulk materials, turn losses to profits.

GLASCOTE subsidiary products for severest chemical processing service ... defeat corrosion and contamination.

MARRIAGE OF GLASS AND STEEL takes place at temperatures up to 1600° F. After preparation, product is coated with special glass mixture called "slip." Then, it's fired in a furnace of unique design. Result — far longer product life ... far broader range of effectiveness.

NEW VERSATILITY FOR STEEL. Specific glass formulas offer severe corrosion-resistance; anti-abrasive, nonstick, dielectrical surface; minimal maintenance; flexibility equal to the yield point of the steel. Bond is both chemical and mechanical to 7500 psi.



- coated steel...

your products

Our research and production facilities may be able to solve your problems. Write for full information ... also free, illustrated booklet, "The Story of Glass-Protected Steel."

steel products ... for home, farm, and industry

PERMAGLAS beer storage tanks ... guard product flavor, purity and uniformity.

Through research ... *a better way*

A.O.Smith

CORPORATION

MILWAUKEE 1, WISCONSIN

12 plants in New Jersey, Pennsylvania, Ohio, Illinois, Wisconsin, Texas and California

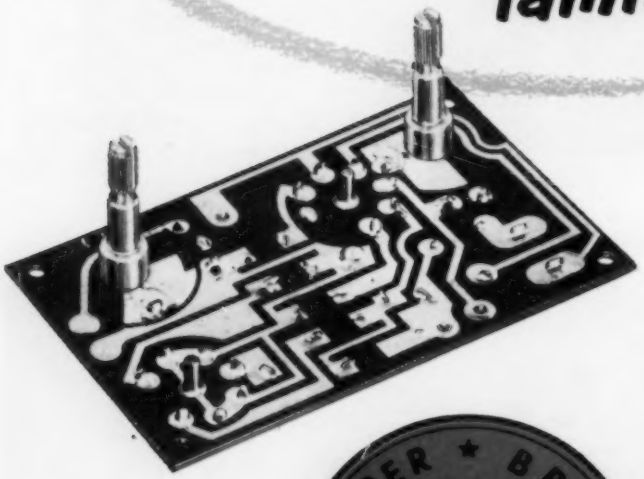
International Division: Milwaukee 1, Wisconsin

PERMAGLAS smokestacks ... answer industry's need for longer smokestack life ... economically.

Taylor Fibre Co.

says...

"Using Revere Rolled Copper we are able to produce superior copper-clad laminates!"



At the top of the page opposite is a section of an etched printed circuit enlarged 10 times. These particular lines are of .008 thickness, spaced .012 apart. They show the kind of printed circuits obtainable by combining Revere Rolled Printed Circuit Copper and Taylor laminates. Note the fine line etching, the close spacing and the sharp definition of the edges . . . the smoother surface (freer from pits, pinholes and imperfections) . . . the more uniform thickness with no sacrifice of conductivity. Results—consistently satisfactory etching at better production rates.

Laminators and users alike also have found that Revere Rolled Copper produces no peaks or valleys, that its smooth, hard surface of uniform density permits resist to clean off easily for there are no pores to hold resist and cause trouble when soldering.

They have noted, too, that Revere Rolled Copper is free from oxidation as it comes from the mill and is without lead inclusions. And because of its clean surface, fluxes wet readily, while in the automatic soldering operation it makes possible a uniform solder coat every time free of skips or bald spots.

Those are the very reasons why you should insist that Revere Rolled Copper be used when ordering blanks from your laminator. It is available in unlimited quantities in standard coils of 350 lbs. in widths up to 38" and in .0015 and .0027 gauges, weighing approximately 1 oz. and 2 oz. per square foot. Revere Rolled Copper exceeds requirements of standard specifications and meets ASTM B5 specification for purity with 99.9% minimum.

REVERE
COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N.Y.

Mills: Baltimore, Md.; Brooklyn, N. Y.; Chicago, Clinton and Joliet, Ill., Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

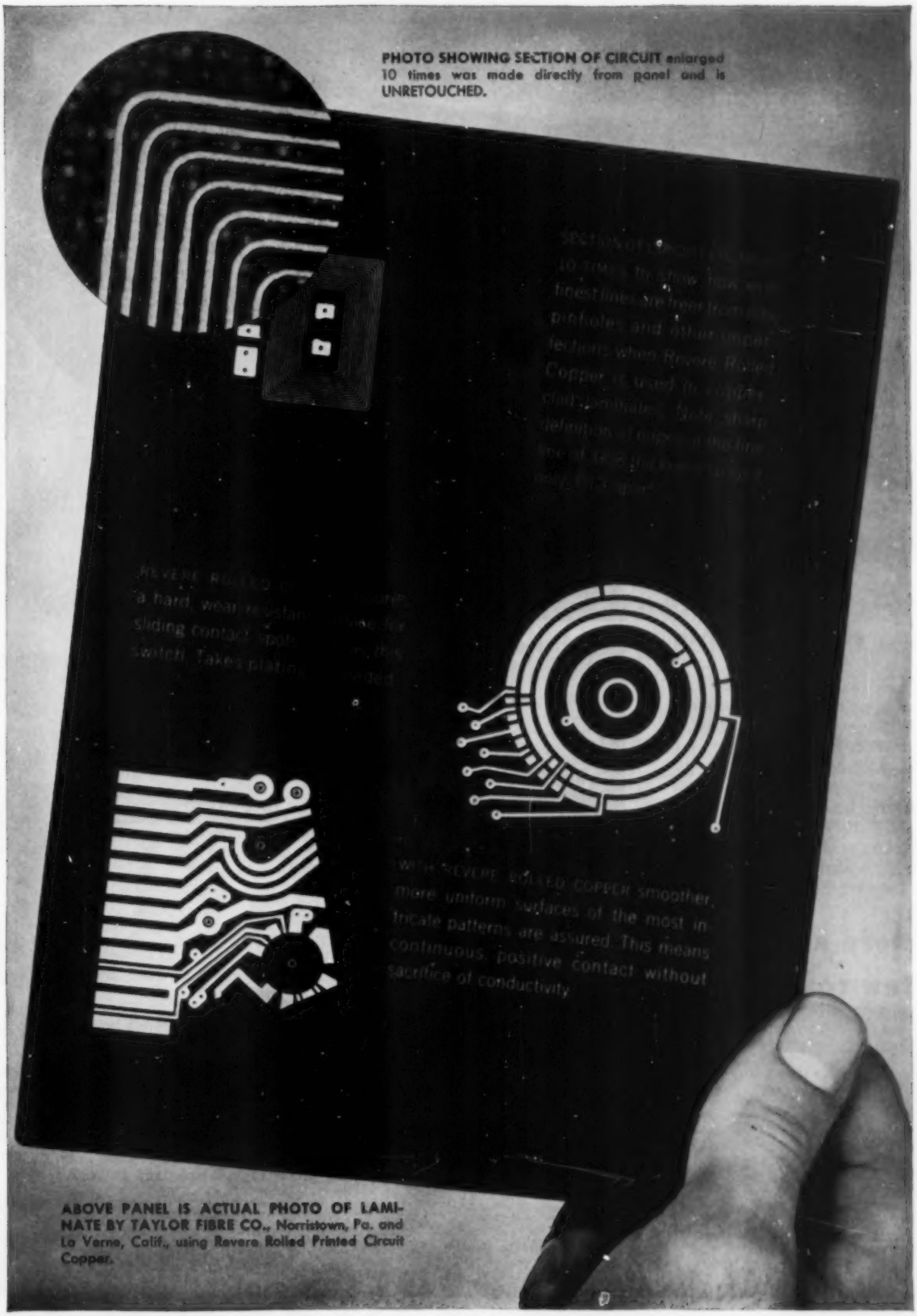
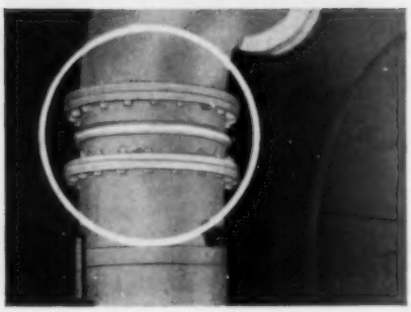


PHOTO SHOWING SECTION OF CIRCUIT enlarged 10 times was made directly from panel and is UNRETOUCHED.
ABOVE PANEL IS ACTUAL PHOTO OF LAMINATE BY TAYLOR FIBRE CO., Norristown, Pa. and La Verne, Calif., using Revere Rolled Printed Circuit Copper.

How long can a U. S. Rubber Expansion Joint last



...some have been on the job since 1926, the year they were invented!

Here are just a few reasons why *these flexible connections are used in pressure or vacuum pipe lines...*

- U. S. Rubber Expansion Joints are resilient and, therefore, do not, like metal, set permanently when compressed.
- Constant flexing merely keeps "U. S." joints "alive"...prevents them from becoming brittle.
- They absorb both axial *and* lateral deflection far more than metal joints. Greater insulation against vibration and pump noises is provided.
- There is never any electrolysis, corrosion or erosion.
- U. S. Rubber joints handle pressures from 40 lbs. to 125 lbs. Compare!
- The outside diameter of the arch is smaller than that on metal joints. Face-to-face dimensions (even with multiple arches) are smaller.
- Weight is much less. This, plus the fact that no gasket is needed between flanges (unlike metal joints) results in a more easy installation, lowering the cost.

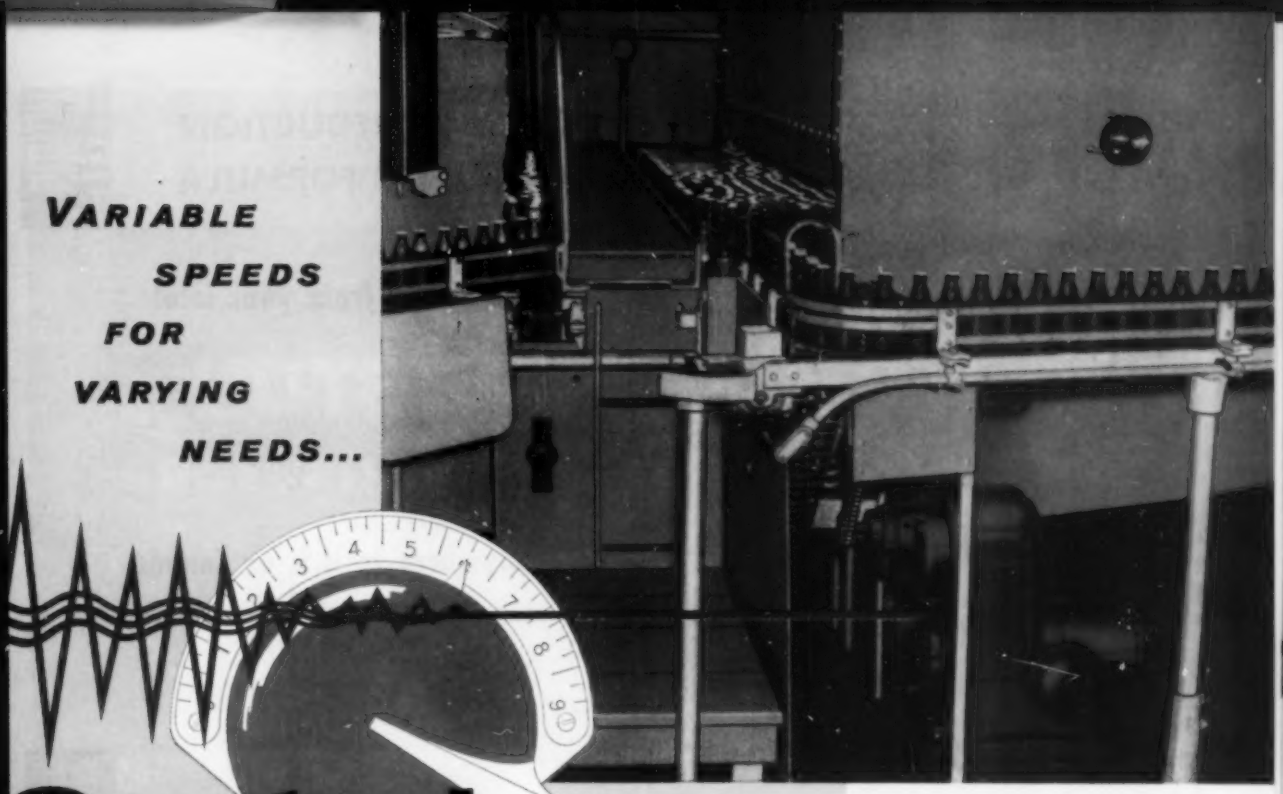
"U. S." was the first to develop rubber expansion joints. They are at work in every kind of industry, prolonging the life of equipment in pressure or vacuum pipe systems. Obtainable at any of the 28 "U. S." District Sales Offices, or write us at Rockefeller Center, New York 20, N. Y.

Watch NCAA football, Saturday afternoons, NBC-TV

US RUBBER

Mechanical Goods Division

United States Rubber



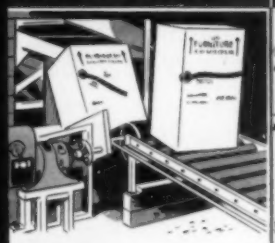
VARIABLE SPEEDS FOR VARYING NEEDS...

Control conveyor speeds with U.S. VARIDRIVES

NOW FAST, NOW SLOW THE BOTTLES GO

Two U. S. Varidrive motors provide the answer to the problem of varying the speed of the circular rotating table and conveyor for this pasteurizer. The use of Varidrives eliminates adjustment troubles and gives the operator accurate control of the conveyor and table, to suit filler or labeler capacity. Varidrives give added versatility to conveyors in all types of industry. Varidrives are available from ¼ to 60 h.p. Speeds 2 to 10,000 rpm.

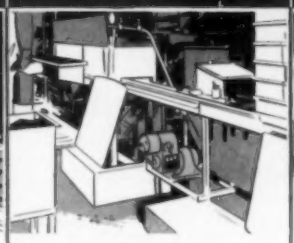
RNITURE CONVEYOR



VARIDRIVE "SETS" THE TEMPO

As loading and packaging requirements vary, a fractional horsepower Varidrive provides just the right speed for this furniture conveyor.

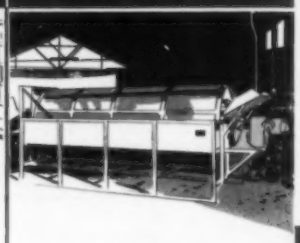
TILE GLAZING



A "CHANGE OF PACE" WITH CONTROL

Since tile glazing time varies, conveyor speeds must also vary. This VA Totally-Enclosed Varidrive powers the tile conveyor at the proper speed for best results.

FOOD INDUSTRY



JUST "SAY WHEN"

In this application a U. S. Varidrive provides maximum production by coordinating the washing operation with the volume of carrots entering the tumbler.

Versatile VARIDRIVE for additional applications:

PUMPING	SPOOLING
PUNCH PRESSES	MIXING & BLENDING
LATHES	CANNING
EXTRUDERS	GRINDING
PACKAGING	VENTILATION
	BUFFING

U.S. Electrical MOTORS

MAIL COUPON NOW

U.S. Electrical Motors Inc. PEN-10
P. O. Box 2058, Los Angeles 54, Calif. or Milford, Conn.

☐ *Send U. S. Varidrive Bulletin #1797*

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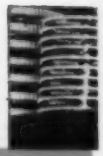
When you plan for COST REDUCTION — use this time-proved FORMULA



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MORE GEARS — Offers 441 standard stock sizes of 20° Pressure Angle Spur, Bevel, and Miter Gears, among many new Gear listings.

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MORE BEARINGS — Lists BOSTON GEAR Bronze Bearings (Bear-N-Bronz) in 1033 stock sizes . . . and new models and sizes in Pillow Blocks, Flanged Cartridges, other products.

MORE HELP IN PLANNING — 50 pages of simplified engineering data make Catalog 56 your reliable aid for drive design, plant maintenance.

Boston Gear Works, 71 Hayward St., Quincy 71, Mass.

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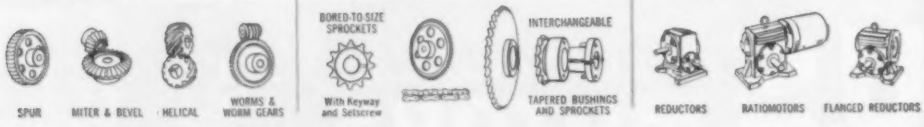

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- You simplify planning
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BOSTON GEAR BRONZE BEARINGS

BALL BEARINGS

PILLOW BLOCKS

— OTHER PRODUCTS —

UNIVERSAL JOINTS

COUPLINGS

Designer Jean Reinecke talks plastics:

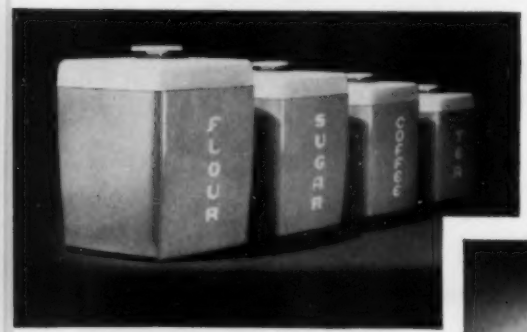
"Plastics have been synonymous with industrial designing for more than 25 years, and as a result have grown into a dynamic sales tool of industry," states J. O. Reinecke, President, Reinecke & Associates, Chicago.

"Designers are using more and more plastics because of their colorability, decorative characteristics and ductility. To cite just one example, plastics circumvent innumerable manufacturing limitations posed by other materials. Plastics can be used to make finished products in one process where other materials require four or five different operations.

"In considering the practical aspects of artistry, engineering and merchandising, cost must enter the picture. In plastics, cost is reduced because there is seldom need to finish or polish, which makes the plastic product less expensive to the consumer than competitive materials. Still another quality in plastics lies in their ever-increasing strength factor . . . opening whole new areas of design and use. To expand the application of plastics, it is necessary to constantly remind engineers and designers of the great adaptability of plastics."

New products are made possible, old products are made better—through the use of plastics. Perhaps one of *your* products can benefit from one of our plastics. Koppers Company manufactures DYLAN® polyethylene, SUPER DYLAN* polyethylene, DYLENE® polystyrene and DYLITE® expandable polystyrene. For more information on any of these products, write to Koppers Company, Inc., Dept. PE-106, Chemical Division, Pittsburgh 19, Pennsylvania.

**Koppers Trademark*



KOPPERS
PLASTICS

Sales Offices: PITTSBURGH · NEW YORK · BOSTON · PHILADELPHIA · ATLANTA
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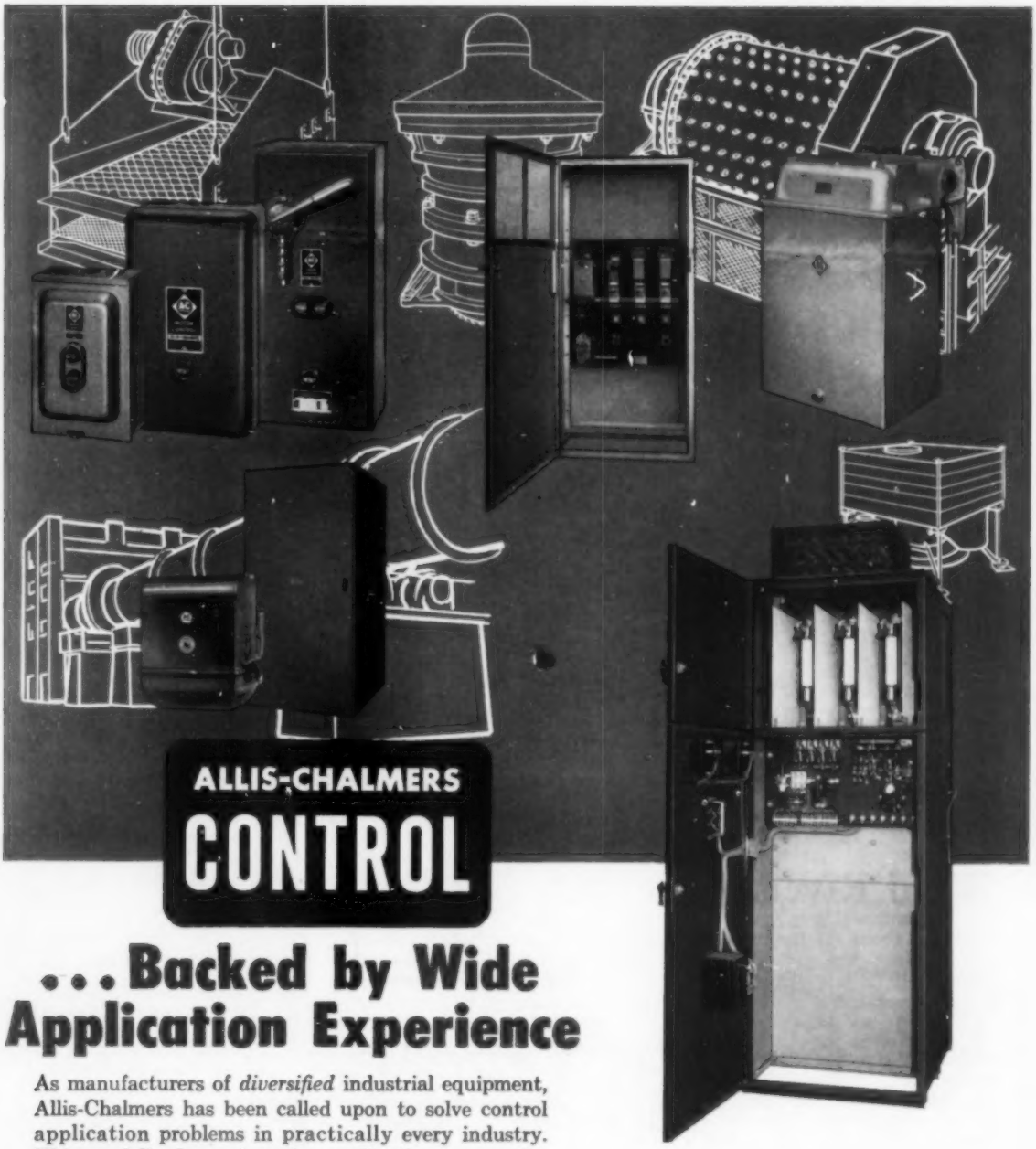
Shown are 3 of more than 15,000 items Mr. Reinecke has had a part in designing during the past 22 years. The canister set (above) and breadbox (right) have won highest awards in the Koppers Annual Design Competitions.



ALLIS-CHALMERS

CONTROL

. . . Backed by Wide Application Experience

As manufacturers of *diversified* industrial equipment, Allis-Chalmers has been called upon to solve control application problems in practically every industry. This specialized experience in coordinating power utilization is *yours* when you specify Allis-Chalmers control.

The Allis-Chalmers line includes control for every condition of motor operation. Functions include full or reduced-voltage starting, acceleration, speed control, reversing or non-reversing, and dynamic braking. Built into Allis-Chalmers control is the type and degree of protection dictated by the application. Controls are available in general-purpose and special enclosures.

A-4587

● For help on a specific control application, call your Allis-Chalmers representative. His recommendations are backed by Allis-Chalmers engineering departments . . . by experience gained in solving thousands of control problems . . . by complete research and testing facilities.

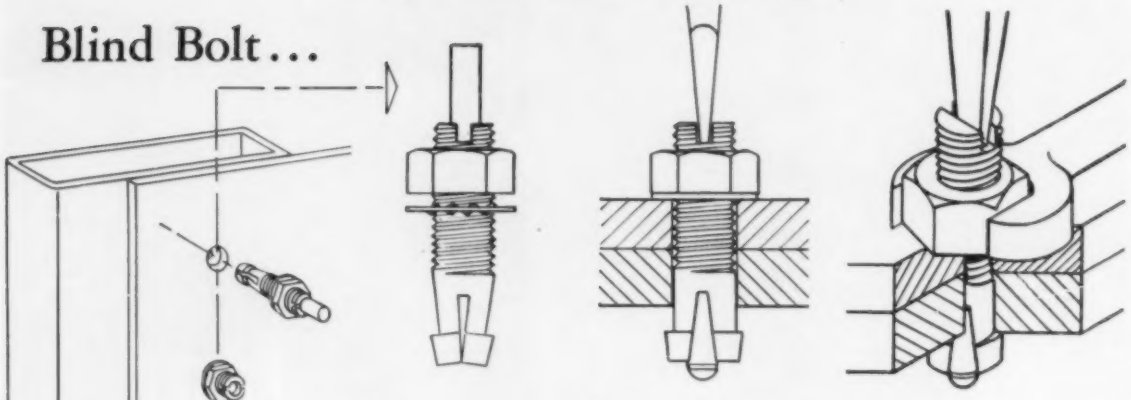
ALLIS-CHALMERS

MILWAUKEE 1, WISCONSIN

Simplified Bolting and Riveting in Blind Applications

For fastener applications accessible only from one side of the work, you can now bolt or rivet without special tools . . .

Blind Bolt . . .

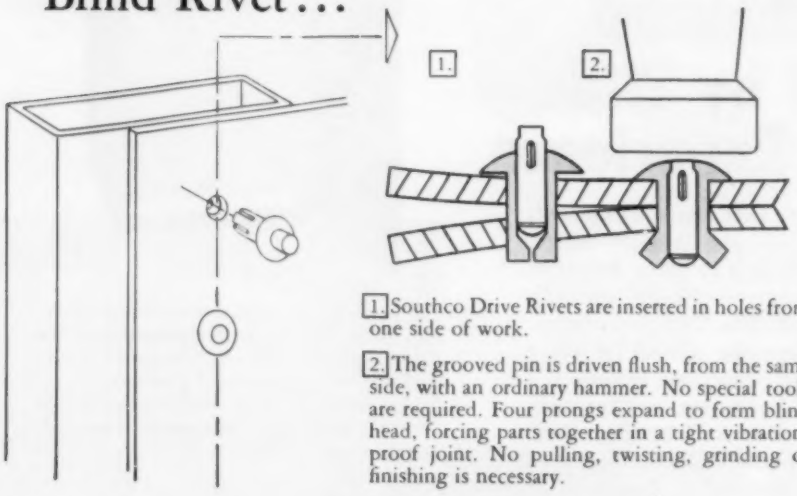


1. This is the Southco "Drivebolt" Fastener. A nut is threaded on and the bolt is inserted from one side of the work.

2. The pin is driven flush, expanding a head on blind side of hole. Pin is then further depressed with screwdriver blade to clear slot.

3. Working from open side, bolt is kept from turning by screwdriver, nut is tightened with wrench. Result—bolted strength achieved from one side of job.

Blind Rivet . . .



1. Southco Drive Rivets are inserted in holes from one side of work.

2. The grooved pin is driven flush, from the same side, with an ordinary hammer. No special tools are required. Four prongs expand to form blind head, forcing parts together in a tight vibration-proof joint. No pulling, twisting, grinding or finishing is necessary.

FREE!

Fastener Handbook

Send for your free copy of Fastener Handbook No 7, just released. Gives complete engineering data on these and many other special fasteners. Fifty-two pages, in two colors.

Write on your letterhead to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS

LION

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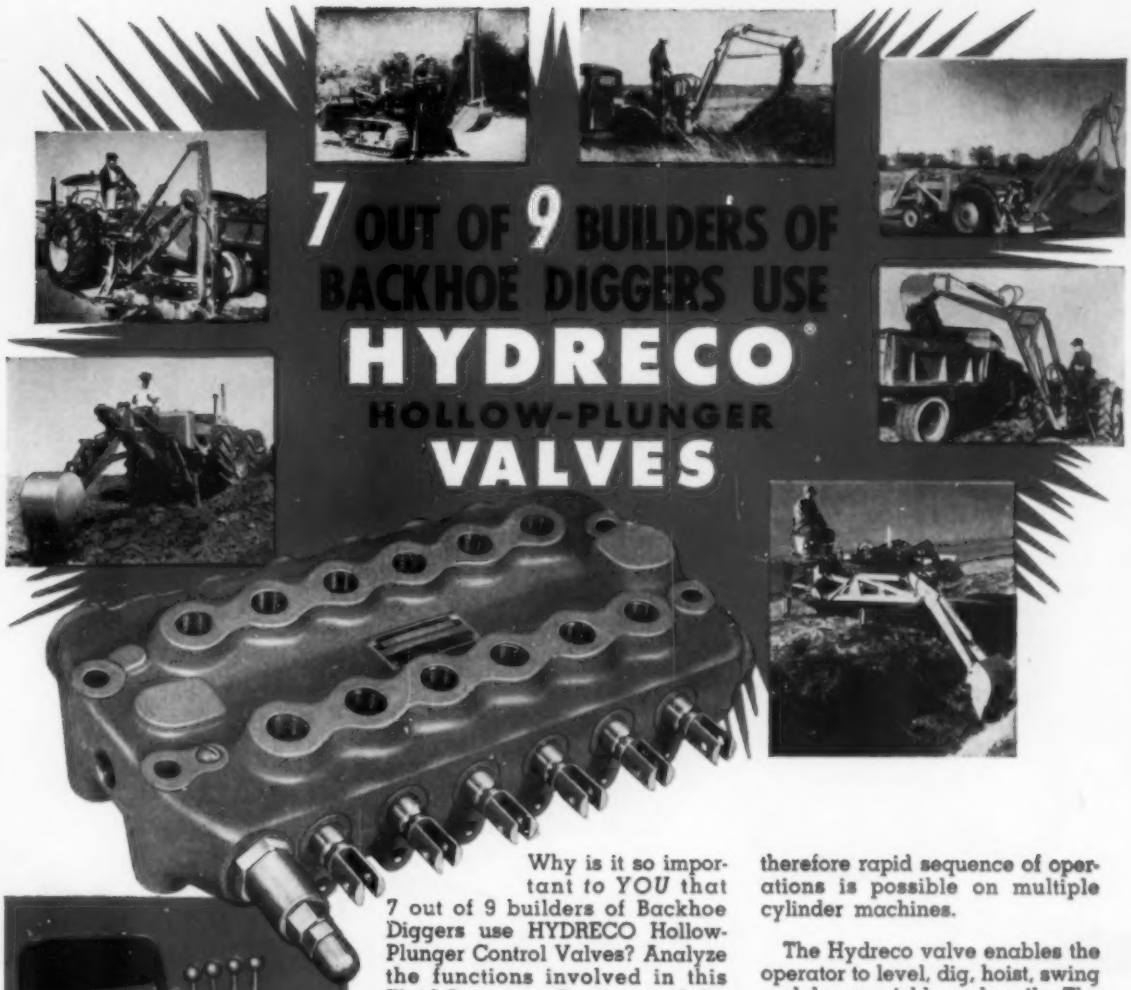


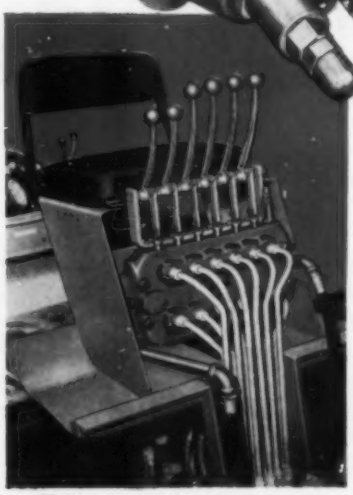
7 OUT OF 9 BUILDERS OF BACKHOE DIGGERS USE HYDRECO® HOLLOW-PLUNGER VALVES

Why is it so important *to YOU* that 7 out of 9 builders of Backhoe Diggers use HYDRECO Hollow-Plunger Control Valves? Analyze the functions involved in this Fluid Power application, and the answer is clear. Here is a rugged service application requiring multiple manual control of Fluid Power operations, good throttling, and easy-to-reach controls. All these features are combined in Hydreco Hollow-Plunger Valves to give the operator a feeling of "playing" the machine.

Hydreco Hollow-Plunger valves are perfect for this application. Check valves built into the plungers absolutely prevent back flow and cross flow between cylinders, therefore rapid sequence of operations is possible on multiple cylinder machines.

The Hydreco valve enables the operator to level, dig, hoist, swing and dump quickly and easily. The operator has the touch he needs to get the best out of a good machine, day in and day out. That's why operators like Hydreco Hollow-Plunger Valves.

Designers like Hydreco valves too, because with all components built in, they come smaller and fit into tight places more easily. For smoother operation, for more work at less cost — apply HYDRECO Hollow-Plunger Valves to your multiple-function equipment!



Hydreco valves are available with up to 6 plungers.

Member NFPA

KALAMAZOO DIVISION
THE NEW YORK AIR BRAKE COMPANY

9012 E. MICHIGAN • KALAMAZOO • MICH.

INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

Kalamazoo Division
The New York Air Brake Company
9012-10 East Michigan
Kalamazoo, Michigan

Kindly send me full information on Hydreco Hollow-Plunger Control Valves.

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

IDEAS...*on making the most of wire cloth!*

● Unless you're in the business up to your ears, you'd hardly be aware of the infinite variations that can be offered today in industrial wire cloth. Not only variations in the wire, metal, weave and mesh, but also in finishes, coatings, roll lengths, widths and packaging. And the *Reynolds Wire Division* of National-Standard has carried this flexibility to a high point in the industry.

So, you can see that it is mighty important for users or fabricators to probe today's possibilities carefully, and to be *sure* they are getting *the* wire cloth that produces best, performs best, minimizes waste, and costs the least for their particular production.

And that is exactly why *Reynolds Wire Division* goes all out in furnishing technical and analytical service—service that benefits customer after customer, small or large. This exceptional service is available coast to coast . . . wherever you are.

Are you open to some ideas on making the most of wire cloth? Do you have any particular production problems in the use of wire cloth? Let's discuss your requirements.

NATIONAL-STANDARD COMPANY • NILES, MICHIGAN
Tire Wire, Stainless, Fabricated Braids and Tape

ATHENIA STEEL DIVISION • CLIFTON, N. J.
Flat, High Carbon, Cold Rolled Spring Steel

REYNOLDS WIRE DIVISION • DIXON, ILLINOIS
Industrial Wire Cloth

NS
NATIONAL-STANDARD Company
NILES, MICHIGAN

WAGNER LITHO MACHINERY • JERSEY CITY, N. J.
Special Machinery for Metal Decorating

WORCESTER WIRE WORKS DIVISION • WORCESTER, MASS.
Round and Shaped Steel Wire, Small Sizes

"designed to take hard knocks"

"Our decision was further based on satisfaction we have enjoyed with other BAKELITE materials used in the SoundScriber system. Chief among these is the high quality vinyl plastic used as our recording discs."

The exterior finish of the "SoundScriber 200" portable dictating machine is *designed* just as are the working parts. It's a specially formulated organosol coating based on BAKELITE Brand Vinyl Resins.

As James J. McKeon, general sales manager of SoundScriber Corporation, New Haven, Conn., explains it: "Exterior appearance was a vital consideration, to give the '200' its high-quality look. Then, too, the unit is soundly engineered. It has to be. It's being taken to the far corners of the world by its users. It's being carried by handle, worn over the shoulder, tucked into auto compartments, packed in suitcases and briefcases. It is imperative that the '200' have a tough, abrasion-resistant finish —one able to take the knocks of travel."

Often, the properties that you seek for a product can be more easily attained by special coatings and finishes, and more economically, than by a structural material. Find out more about the unusual jobs done by organosol coatings. Write for the booklet, "BAKELITE Dispersion Resin Coatings," to Dept. UG-145.

BAKELITE
BRAND
RESINS for COATINGS

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC.

NEW THREAD CUTTING FASTENER

- LOW COST
- RE-USABLE
- SELF-LOCKING
- VIBRATION-PROOF
- SPRING TAKE-UP

Pulls up tight without backup on flat or contoured surfaces

Specially designed to hold die-cast or cold-forged name plates, emblems and trim against sheet metal surfaces, DOT's new T. C. F. cuts clean, deep threads on unthreaded studs, even those that are chrome plated. Immediately available to fit 1/8" and 3/16" studs.

When used with its pre-assembled plastic sealer, the new T. C. F. makes a watertight seal. The sealer *precedes* the fastener onto the stud so that it is not damaged by the thread-cutting process.

Available *in quantity* with or without sealer from Monadnock Mills subsidiary and Carr Fastener Division.

United-Carr's design staff is ready to apply the same engineering creativity that produced the T. C. F. and thousands of other special-purpose fastening devices to the solution of your special fastening problems. Field representatives are located in most principal cities.

T.C.F. for 1/8" stud shown actual size. Also available for 3/16" stud.

T.C.F. for 1/8" stud with plastic sealer.

MONADNOCK MILLS
SUBSIDIARY
San Leandro, California

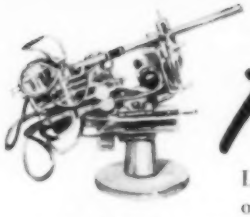
DOT T.C.F.
THREAD CUTTING FASTENER

CARR FASTENER CO.
DIVISION
Cambridge, Massachusetts

UNITED-CARR FASTENER CORPORATION

A LOW-POROSITY, WEAR-RESISTANT ALUMINUM OXIDE COATING

In LINDE's Flame-Plating process, particles of the coating material are literally *blasted* onto the workpiece.



Flame-Plating by Linde
Trade-Mark

LINDE's Flame-Plating method of coating metal surfaces now provides extra wear resistance for parts subject to extremely hard wear and high temperatures. This new high-purity aluminum oxide coating, blasted from the Flame-Plating gun, builds up on the workpiece in desired thicknesses from .002 to .040 inch. With a porosity of *less than 1 per cent*, the aluminum oxide coating can be used at temperatures up to 1750 degrees F.

The hardness of aluminum oxide coatings, Flame-Plated by LINDE, ranges from 1000 to 1200 VPN. Metallurgical properties of the base metal are not modified by the Flame-Plating process because the part being plated always remains at a temperature of 400° F. or below. The bond between coating and base metal is exceptionally strong with aluminum. Aluminum oxide coatings can be used in as-coated condition (approximately 120 microinches rms), or finished to better than 1 microinch rms.

Flame-Plated coatings of aluminum oxide provide resistance to wear, and to chemical action in high temperature applications. Applications are found in thrust bearings, pump plungers, thermocouple tubes, gas turbines, guided missiles, and other devices. Either aluminum oxide or tungsten carbide can be Flame-Plated on most metals. If you have a special wear problem, LINDE's Flame-Plating Department will gladly help you to reach a solution. Write to "Flame-Plating Department P-10."

LINDE AIR PRODUCTS COMPANY

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, New York

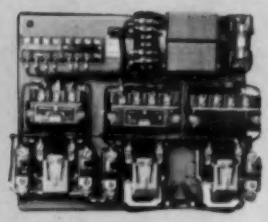
In Canada: Linde Air Products Company, Division of Union Carbide Canada Limited, Toronto

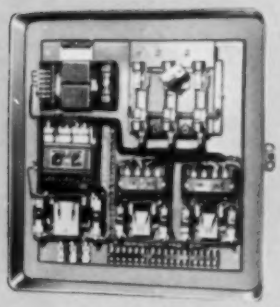
The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

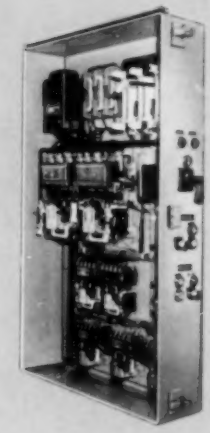
Flame-Plating by Linde

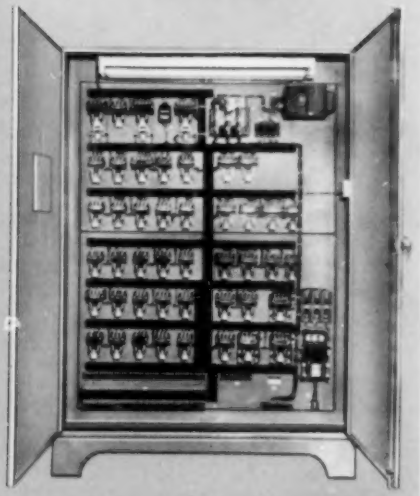
G-E general purpose control on

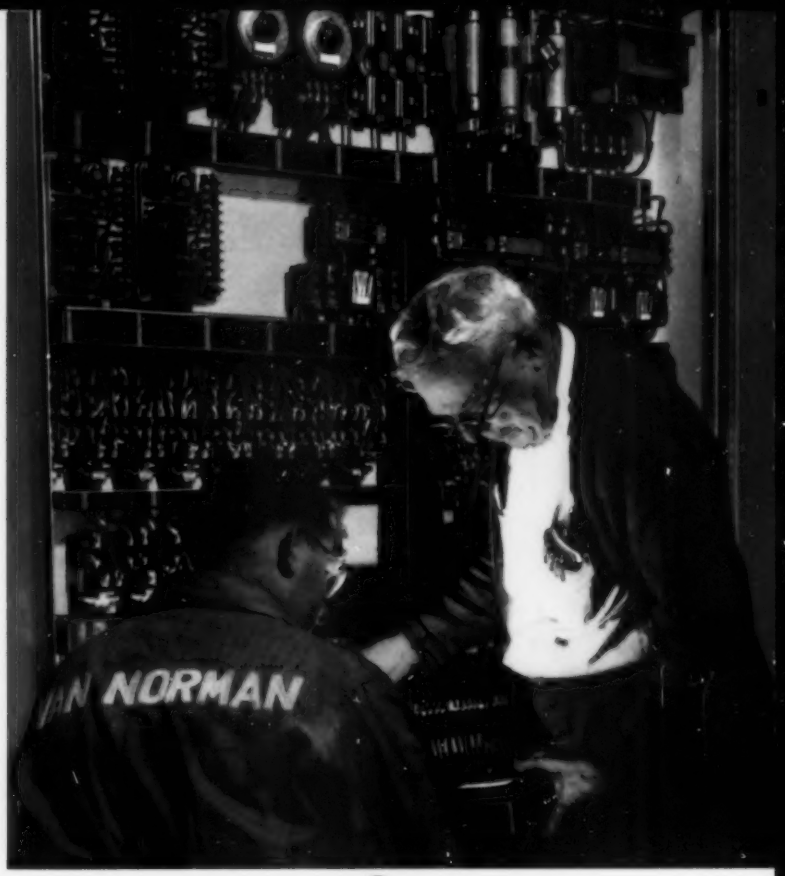
TYPICAL PANELS

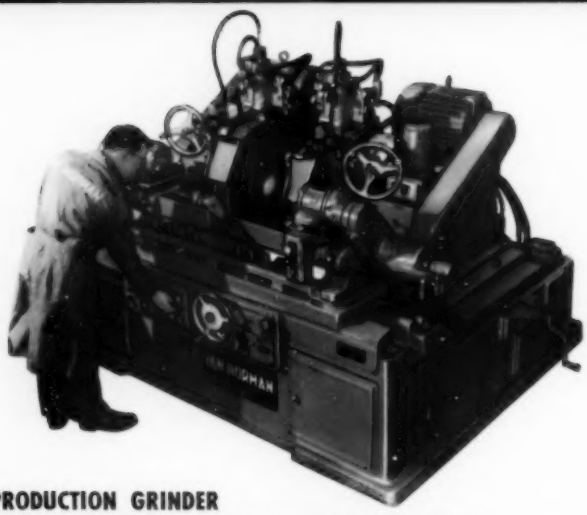












NEW HIGH PRODUCTION GRINDER
EQUIPPED WITH G-E CONTROL HOLDS 15 MICROINCH FINISH

This new Van Norman Bowgage Production Grinder is designed for high production grinding of any part that can be readily chucked. The grinder can remove 0.022-inch on a 1⅝-inch diameter piece, hold a 15 microinch finish, and with operator initiated automatic clamping can have a new piece ready for grinding every 15 seconds.

Manufactured by the Van Norman Machine Co., Springfield, Mass., the Bowgage Production Grinder provides the equivalent of two Single Head Production Grinders on a single base. This reduces the floor space required, operator fatigue, handling time, and maintenance.

machines for industry

NEW G-E PAN-A-TROL* PANELS

A new program for packaged machine control from General Electric

Pan-A-trol panels are the focal point of a new program from General Electric for packaged machine control. This program, which places a new emphasis on panels for the dynamic automation age, features outstanding service to customers. The Pan-A-trol name distinguishes these panels which are applied to machines with a maximum rating of 200 horsepower, 600 volts, a-c.

This new program emphasizes the General Electric services available to you with Pan-A-trol packaged control. An enlarged engineering staff is ready to work with you on developing a circuit and panel design to meet your machine requirements. These G-E engineers can also help you take advantage of cost reductions due to repetitive or quantity Pan-A-trol orders.

Faster and better factory service is provided by expanded manufacturing facilities. Up-to-date equipment and skilled employees assure you of fast, prompt shipment. And, of course, General Electric's field service organizations assure your customers of fast local service if desired.

PAN-A-TROL NAMEPLATE identifies each panel. Built from your specifications, these panels offer you the installation, maintenance, and reduced stocking benefits of packaged control.

See your G-E Apparatus Salesman about this new program, and let him tell you how you can benefit from Pan-A-trol packaged control. And, write Section 731-3 for bulletin GEA-6334. General Purpose Control Department, General Electric Company, Bloomington, Illinois.

*Reg. trade-name of General Electric Co.

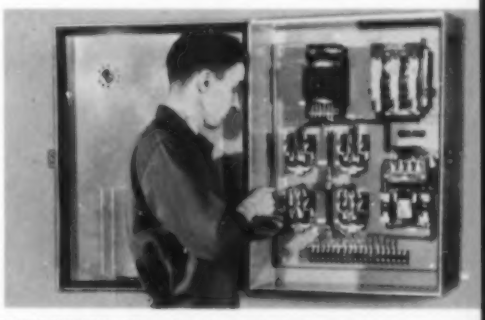
Progress Is Our Most Important Product

GENERAL ELECTRIC

4 WAYS TO BENEFIT WITH PAN-A-TROL PANELS

ENGINEERING ASSISTANCE. An enlarged staff of General Electric engineers in the factory and local offices are ready to help you with Pan-A-trol panels for specific applications.

MANUFACTURING FACILITIES. Skilled employees in new, enlarged factory facilities with the latest manufacturing methods assure fast, prompt shipment for Pan-A-trol control panels.

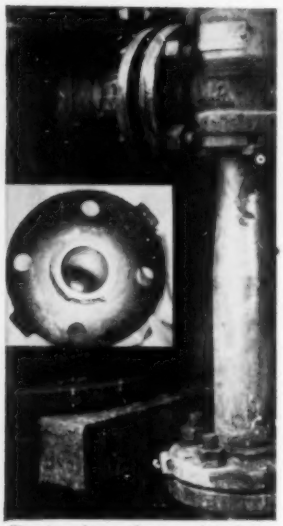


UNIT DESIGN. Pan-A-trol packaged control combines circuit design, device selection and arrangement into one coordinated unit. Only connections to rest of machine need be made.

PAN-A-TROL QUALITY. High-quality components and construction, backed by General Electric's field services, assure long dependable performance with Pan-A-trol packaged control.

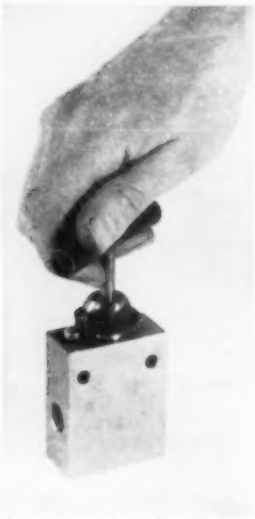
MALLORY·SHARON

reports on # TITANIUM



Titanium bore of steam jet ejector installed at DuPont shows no corrosion despite exposure to hydrochloric acid and high velocity steam. Previously, bore of different material had to be replaced frequently. Compare titanium bore to cast-iron flange.

Use of titanium in an anodizing rack has increased useful life from forty-five hours to one year. The sulphuric acid electrolyte used in anodizing operations quickly attacked the material previously used. Made by R. W. Renton Co.



Valve made of titanium for handling corrosive materials. Titanium is now much easier to fabricate than it was even a year ago. Thus piping, tubing, and complicated fittings are now available. Made by Autoclave Engineers, Inc.

Where use of Titanium piping is indicated, it can mean fewer shutdowns, contribute to safer operation. These Ladish Seamless Butt Welding Fittings, by Ladish Co., show versatility in fabrication of variety of fittings . . . elbow, tee, cap, and reducer.

Where **TITANIUM** *stops corrosion*

DESIGN AWAY CORROSION WITH TITANIUM

New booklet lists available data on titanium's corrosion-resistant properties, shows typical applications, and includes corrosion data charts covering behavior with many common acids and industrial chemicals. For free copy write Mallory-Sharon Titanium Corporation, Dept. P-1, Niles, Ohio.

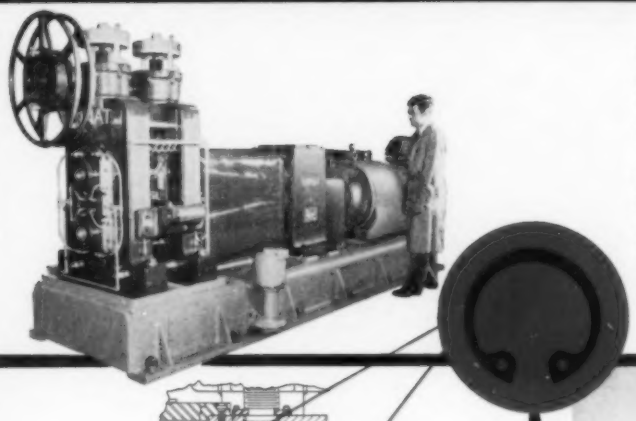
• Titanium offers outstanding resistance to many common corrosive media, including some of the most troublesome industrial chemicals — nitric acid, moist chlorine, chlorinated organic or inorganic compounds, etc. Titanium is not susceptible to stress corrosion, and resists pitting attacks in solutions which affect other metals.

Use of this new metal can end costly shutdowns, replacements, and hazards from corroded parts. Wherever corrosion presents a tough problem, we suggest you investigate titanium. Write and tell us the nature of your corrosion problem—our service engineering group can furnish technical data, and will propose a plan for economical evaluation.

MALLORY-SHARON TITANIUM CORPORATION, NILES, OHIO

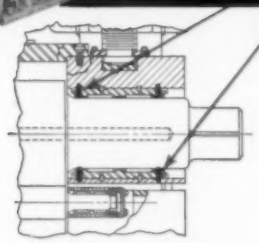
MALLORY Ti SHARON

7-inch Waldes Truarc retaining rings cut costs, speed assembly-disassembly of 2-high/4-high mill



New Model TA-625 2-high/4-high combination rolling mill designed by Stanat Manufacturing Co., Long Island City, N. Y., reduces 2½" ingot to precision-rolled strip as thin as .001".

Waldes Truarc retaining rings help make possible a complete change of work rolls in 20 minutes... solve difficult problems of accuracy control by achieving positive location of bearings to extremely close tolerances. Rings eliminate costly parts and machining, save space, reduce maintenance.



In the assembly illustrated above, 7" Waldes Truarc (Series 5000) retaining rings—three on each roller—are used to position heavy-duty needle bearings in the bearing housing. Smaller rings position bearings in other roller assemblies and retain the shaft of a dual handwheel screwdown. All in all, 18 Waldes Truarc rings are used in the mill. They replace machined shoulders, spacers and lock nuts... eliminate costly threading, other machining operations.

Assembly is simple, even with giant 7" diameter Truarc ring. Special Truarc ratchet pliers grasp the ring securely, ease it into the groove, snap it securely into position. Smaller pliers and various high-speed assembly jigs are available for other rings, permit assembly-disassembly to be performed rapidly even by unskilled labor.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. Quick and easy to assemble and disassemble, they do a better job of holding parts together. Truarc rings are precision-engineered and precision-made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U.S.A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!

WALDES TRUARC® RETAINING RINGS

© 1956 Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C.1, N.Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name _____
Title _____
Company _____
Business Address _____
City _____ *Zone* _____ *State* _____

PN108

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

265 Westinghouse warehouses
stock the *Life-Linestarter* ...

Here it is. The most advanced starter on the market. And it's ready for immediate shipment. Available in a uniform and complete line backed by Westinghouse application and service facilities. The Life-Linestarter* is the starter you can install and forget.

Among its outstanding features are De-ion* arc quenching and the exclusive knife-edge bearing design which greatly reduces friction and wear. You are assured of long life, ease of installation and maintenance, and instant, positive motor protection.

Get this magnetic motor control by calling your Westinghouse sales engineer and placing your order. Call him today. *Trade-Mark
J-21929

WATCH WESTINGHOUSE!

COVER THE PRESIDENTIAL CAMPAIGN ON CBS TV AND RADIO!

which part should be made of metal powder?

We ask: **How will it be used in the end product of which it will be a component?** What are the loads, tolerances, and shape of the individual part? How will it be lubricated? Are there any special requirements such as hardness and finish? Do the quantities justify tooling costs?

These are the questions that were answered before any decisions were made on the parts shown above —both of which are made of metal powder.

Because Moraine Products can draw upon a wide range of experience with many different mass production processes and their applications to specific problems, our judgment on these questions can be considered sound. When we recommend metal powder, it is because we are convinced, in our own minds, that it is the material and the process best suited for the job the specific part must do.

Moraine Products also produces: Moraine Power Brakes—Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts—Moraine friction materials—Moraine-400 and M-100 automotive engine bearings—self-lubricating bearings and porous metal filters—rolled bronze and bi-metal bushings.

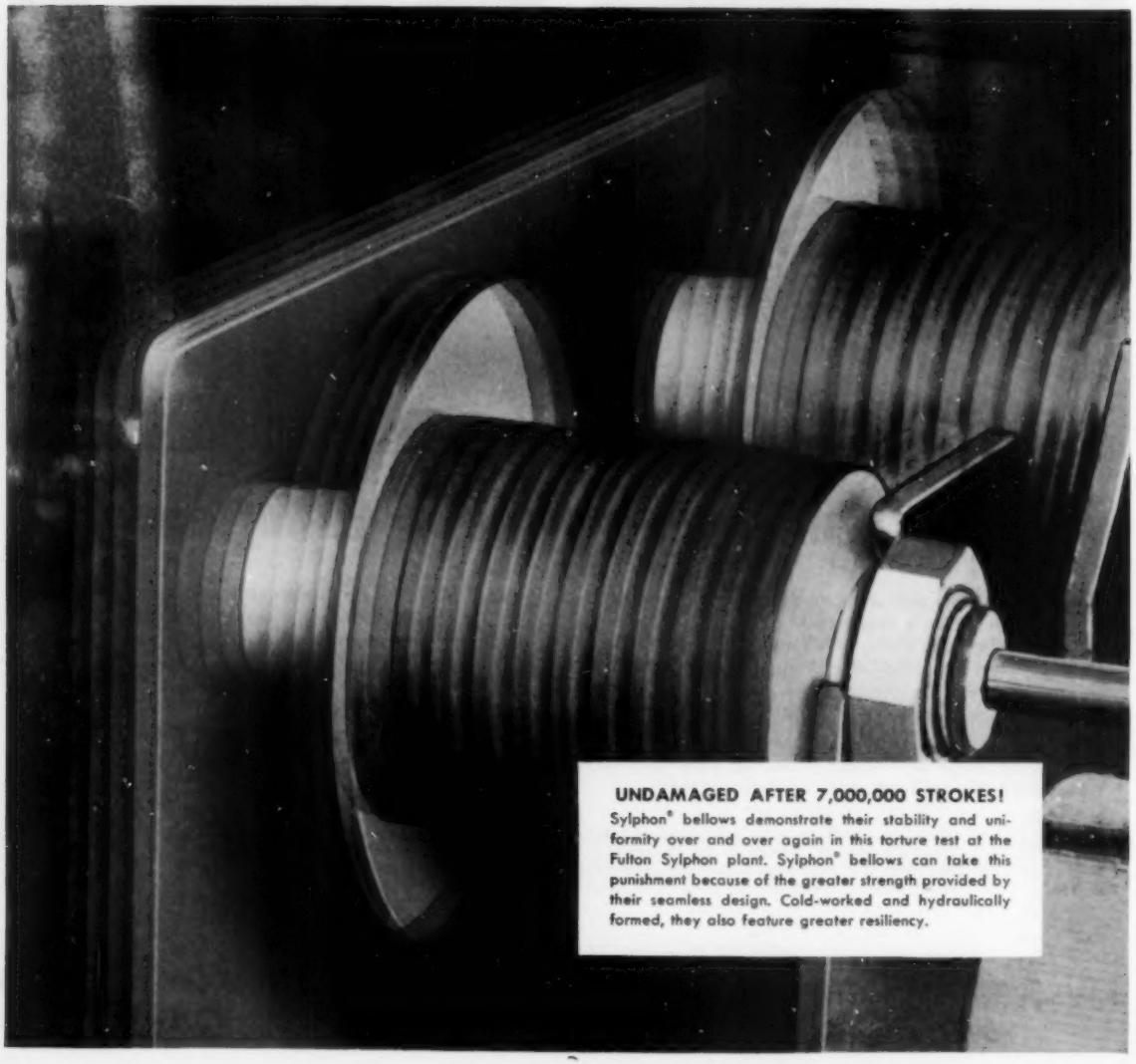
Another General Motors Value

Moraine Products
Division of General Motors, Dayton, Ohio

FULTON SYLPHON

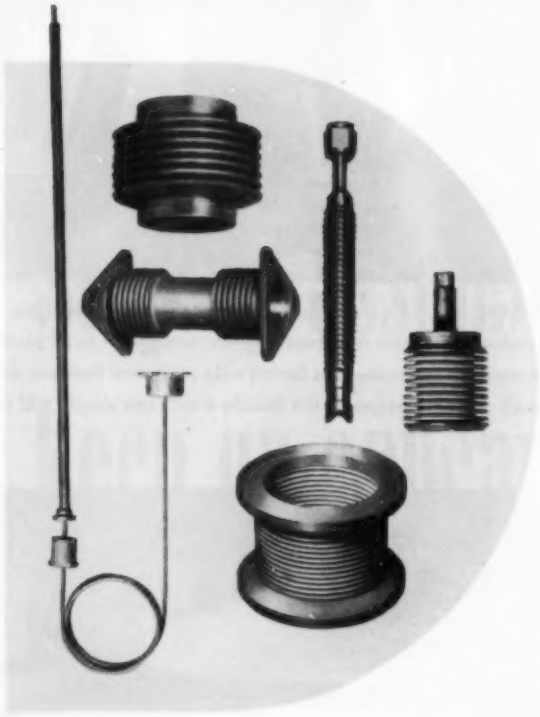
BELLOWS ASSEMBLIES

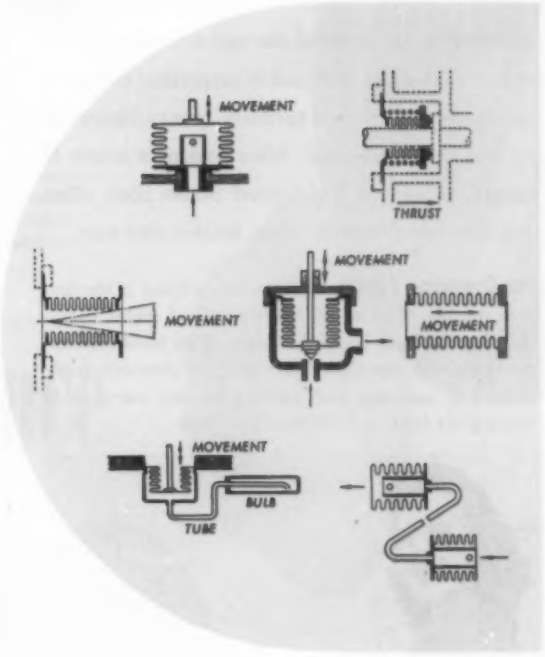
With Fulton Sylphon *complete* bellows assemblies, you get added assurance that all their dimensional and operating accuracy will be retained in guided missile, aircraft, nuclear power, and other torturous applications. A wider-than-ever choice of standard and special metals now enables you to obtain unmatched uniformity and long-term stability even with constant cycling or extreme temperature and pressure conditions. Whatever the metal . . . whatever the bellows function . . . you also get the benefit of big cost savings by letting Fulton Sylphon produce the assembly complete with bellows and all accessory parts.



UNDAMAGED AFTER 7,000,000 STROKES!
Sylphon® bellows demonstrate their stability and uniformity over and over again in this torture test at the Fulton Sylphon plant. Sylphon® bellows can take this punishment because of the greater strength provided by their seamless design. Cold-worked and hydraulically formed, they also feature greater resiliency.

offer longer life in a wide range of metals





METALS FOR TAME OR TOUGH APPLICATIONS!

Whether they're to be used in the most delicate instrument or the most rugged equipment, Fulton Sylphon bellows assemblies are fabricated in the best metal for the application . . . brass, phosphor bronze, copper, beryllium copper, monel, stainless steel and other appropriate metals to suit the job. For added protection against extremely high pressures, strength of the metal itself can be multiplied by forming the bellows in multiple plies. Special solders or welded construction also are available to make the entire assembly uniformly resistant to temperatures up to 500°F. and higher.

ASSEMBLIES IN MANY DIFFERENT DESIGNS!

The accuracy, stability, and uniformity of Fulton Sylphon bellows assemblies can be used advantageously in converting or absorbing temperature or pressure effects; absorbing expansion, shock or vibration; sealing shafts and joints; and performing many other functions. Instead of buying bellows and assembling them yourself, let Fulton Sylphon do it. With its highly specialized facilities and fabrication experience, Fulton Sylphon can invariably save you money by producing the assembly complete with ends, brackets, flanges, tubing, bulbs, or other accessory parts.

SEND TODAY FOR BULLETIN TP-1400

Mr. Controls

Robertshaw-Fulton CONTROLS COMPANY

FULTON SYLPHON DIVISION

Knoxville 1, Tennessee

FULTON SYLPHON • BELLOWS HEADQUARTERS U.S.A.

NOTHING *can equal* *Stainless Steel*

for its combination of desirable properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When seeking a source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

For Consumer Appeal. General Ionics Corp. is the first company to offer an all Stainless Steel water conditioner. Sales have boomed because of its handsome appearance and complete freedom from corrosion problems. The company even offers a 10-year warranty to prove their faith in USS Stainless Steel.

For Long Life. All over the country, dairies are switching to Stainless Steel milk cans because they never have to be plated, the smooth surface does not harbor milk solids and bacteria, and, for all practical purposes, the Stainless milk can simply will not wear out.

For Corrosion Resistance. Laboratory fume hoods at the New Jersey Zinc Company used to last no more than 18 months—and sometimes they looked like sieves after only three months. They replaced the hoods and piping with Stainless Steel, and after five years they still look like new.

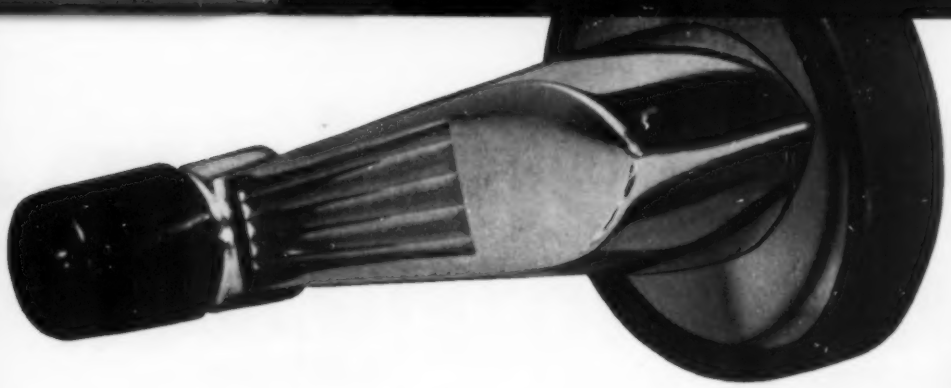
UNITED STATES STEEL CORPORATION, PITTSBURGH
AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

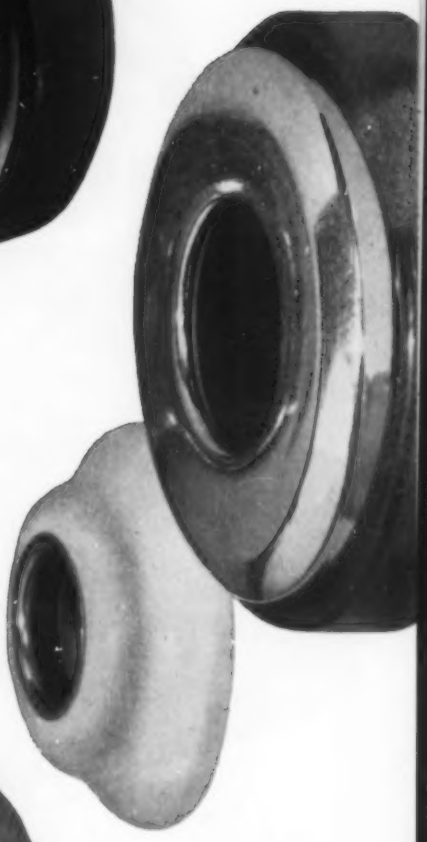
USS

UNITED STATES STEEL



Flexible Vinyl Escutcheons

Step up assembly keep up appearance



Installing these flexible escutcheons for auto and truck door handles is a fast operation. No springs are needed to hold them in position. There's no breakage. Metal ferrules are simply snapped into place, often at the rate of 1500 units per hour.

These examples are injection molded from BAKELITE Brand Elastomeric Vinyl Plastic VND-9960. Notice their extremely high gloss. They come in a wide variety of colors, including striking metallic effects.

BAKELITE Elastomeric Vinyl Plastics are available in several formulations to cover a wide range of applications. Their flexibility can be varied from semi-rigid to soft. Finishes can be glossy or matte. Transparent, translucent, or opaque effects can be achieved. These materials also possess good dielectric strength and resistance to water, oil, and many corrosive chemicals.

Does your product call for this combination of service properties and eye-appeal *plus* production economy? Get detailed information on BAKELITE Elastomeric Vinyl Plastics by writing Dept. UM145. For assistance in solving your specific problem, you can call on the aid of qualified Bakelite Company Technical Representatives.

Automotive door handle escutcheons molded by **The Jim Robbins Co.**, Detroit, Mich., for **Automotive Appliance Co.**, Detroit, Mich.

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3000 psi, Series PF-3006 hydraulic pump . . . gives you new economies . . . new design flexibility

SERIES PF-3006 SPECIFICATIONS

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Rated pressure (psi)	2000
Displacement per rev. (cu. in.)	.597
Max. rpm	2600
Gpm @ 1200 rpm	2.8
Gpm @ 1800 rpm	4.15
Max. hyd. hp	8.6
Weight (lbs)	25

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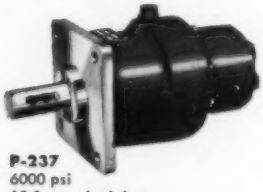
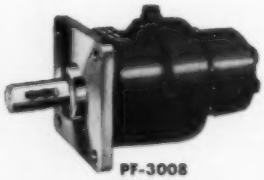


P-237
6000 psi
13.8 max. hyd. hp



PF-3008
3000 psi
13.8 max. hyd. hp

P-280
6000 psi
24.5 max. hyd. hp

PF-3016
3000 psi
24.5 max. hyd. hp

P-240
6000 psi
33.0 max. hyd. hp

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a development of the HYDRAULIC CONTROL DIVISION of

BLACKHAWK®

• a revolutionary new piston pump at a remarkably low price

At last a piston pump in the price range of gear and vane types

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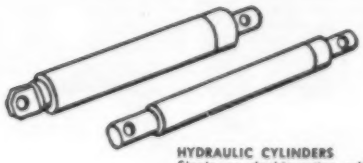
The PF-3006 is especially adaptable to agricultural equipment, construction machinery, materials handling devices, test stands and presses. Shaft rotation can be in either direction. It can be mounted in any position. Fitting adapters available with SAE straight threads or pipe threads.

For full details write for Bulletin No. PF-3006.

Blackhawk is your source for these and other hydraulic components



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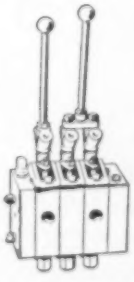

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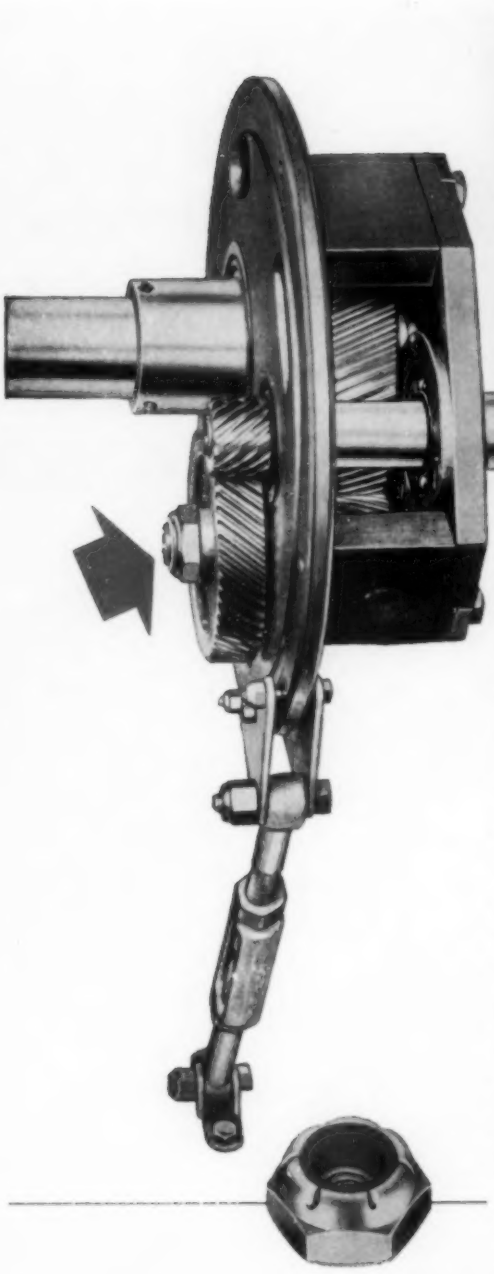

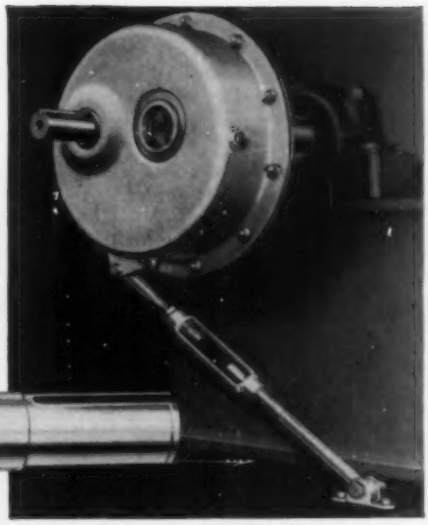

The Falk Corp., of Milwaukee, also uses Elastic Stop nuts in the tie rod assembly . . . and on the gear housing to maintain tight cover fit.

Elastic Stop® nuts solve critical gear adjustment problem in new speed-reducing unit!

In its rugged new Shaft-Mounted Drive, The Falk Corporation uses a self-locking Elastic Stop nut to secure the high-speed gear to the intermediate shaft, as shown in the illustration on the left.

The precision-made Elastic Stop nut stays firmly in place and the close seat-squareness tolerances maintain the exact original gear adjustment withstanding severe vibration caused by shock loads transmitted through the gears. Costs are cut because drilled bolt holes and cotter pins are eliminated.

Here's how this Elastic Stop nut works: The familiar red collar of the Elastic Stop nut is deliberately undersized in relation to the shaft (or bolt) diameter. It grips the shaft with a perfect fit, enforces a continuing self-locking pressure against the metal threads, and holds the nut securely in place at the desired point on the shaft. This same tight-fitting locking collar also provides a seal that prevents oil from seeping along the bolt threads, wherever oil seepage is a problem. And because the bolt threads are protected against moisture from without, the nuts cannot become "frozen" to the bolt by corrosion. The elastic recovery of the red collar permits extended re-use of Elastic Stop nuts.

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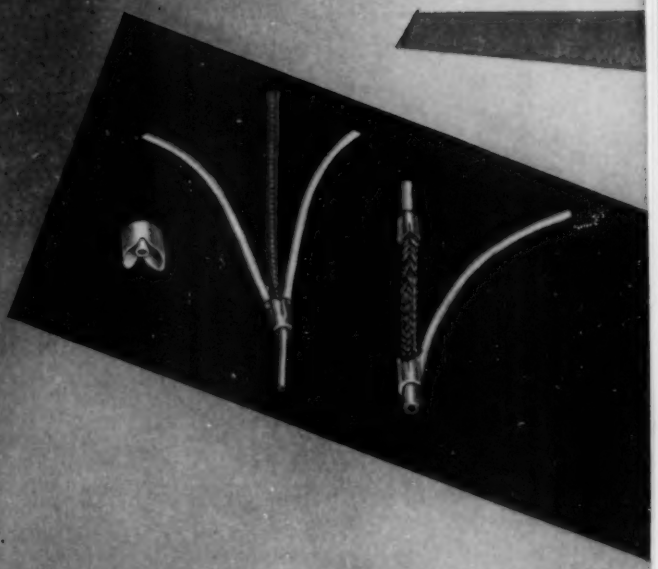
for the aircraft and



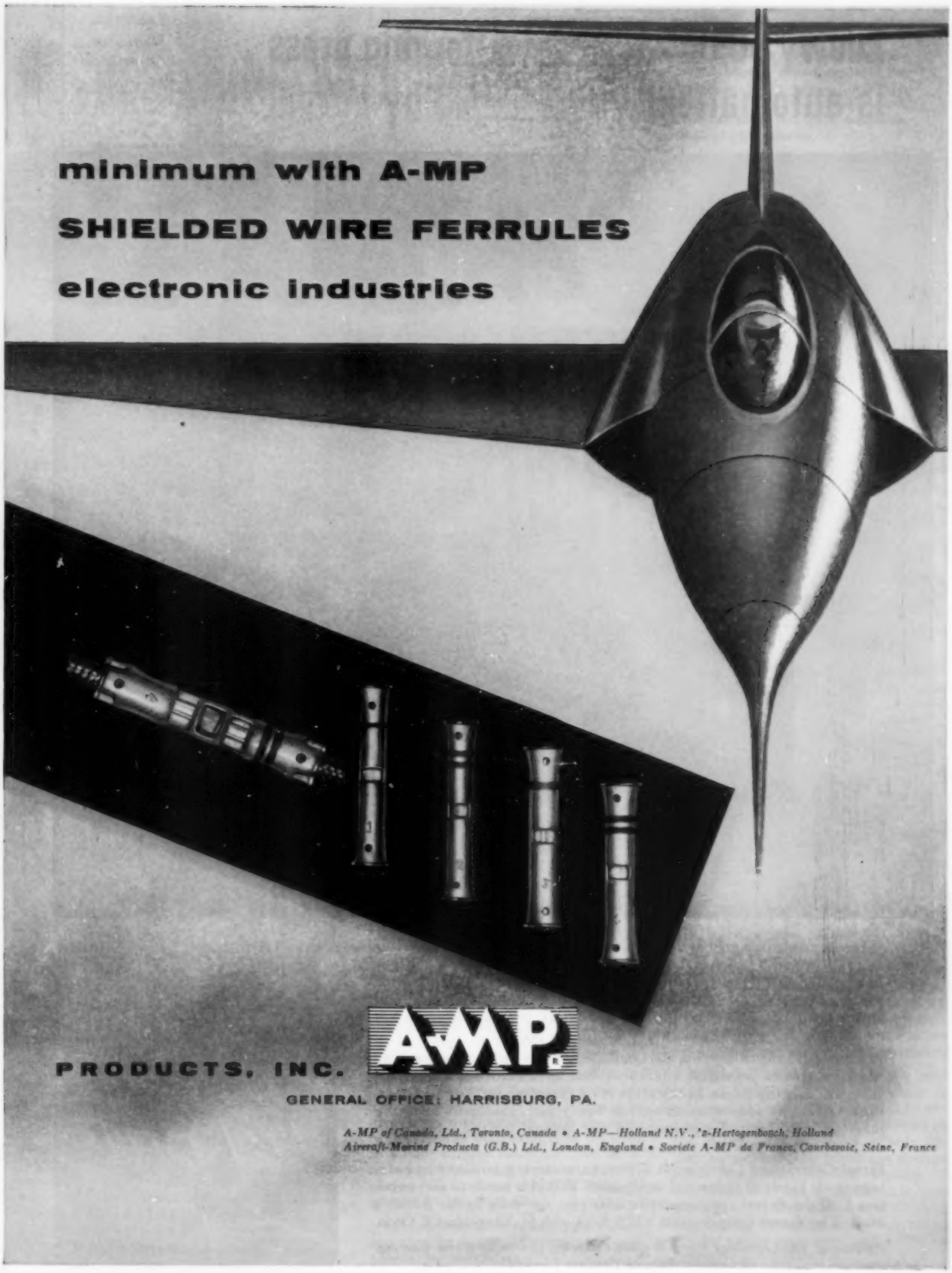
This newest team of A-MP connectors is crimped onto shielded wires making permanent mechanical and electrical connections. More than three and one-half years of engineering and development have gone into these new A-MP shielded wire parts, with advantages that minimize application time and costs. There are no loose pieces required to make connections. A splice between two shielded wires is completed by crimping the connector on each end with a recommended A-MP hand crimping tool or appropriate power tooling. Grounding connections are made with the Shielded Wire Ferrule and similar tooling.

The new A-MP Shielded Wire Connectors and Shielded Wire Ferrules incorporate several new features which facilitate inspection and selection of the proper connector and ferrule. These are: color coding to identify wire sizes and inspection ports to establish definitely and positively the depth of the braid which is enclosed after crimping.

A rectangular window in the center of the Shielded Wire Splice enables the operator or inspector to see at a glance if the ends of the inner conductors are properly placed.

The new A-MP Shielded Wire team proves to be the answer to faster, more compact splicing with resultant superior performance.

AIRCRAFT-MARINE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Loewy 50,000-ton "Major" forging press is automatically lubricated by Farval

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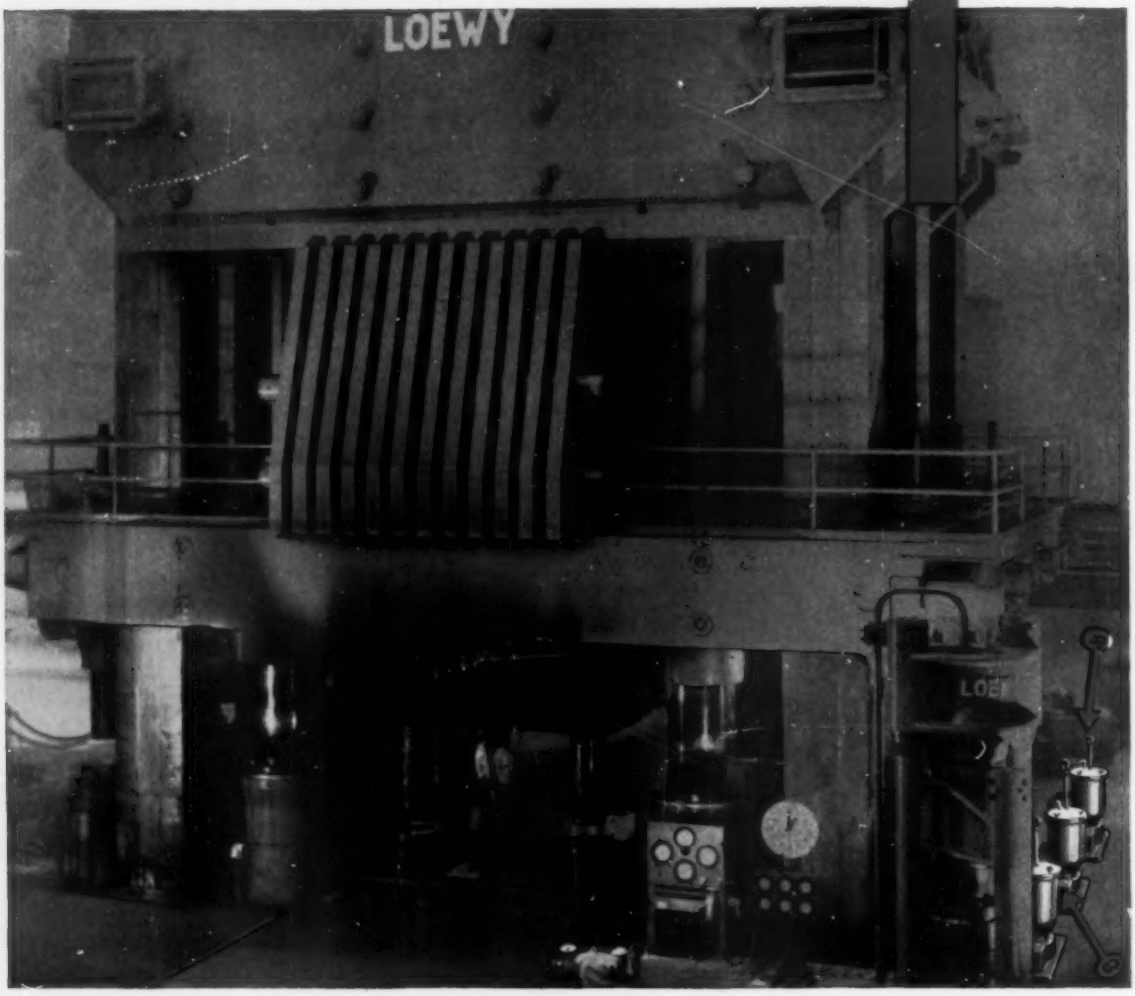
Studies in Centralized Lubrication
No. 196



● It takes only one man at the control pulpit to operate this huge 11-story press—the world's largest machine. Designed and built by Loewy-Hydropress Div. Baldwin-Lima-Hamilton of New York for the U.S.A.F. Heavy Press Program and operated by the Wyman-Gordon Co., it can exert 108 million pounds' pressure to form hot aluminum billets into structural parts for jet planes.

Adequate lubrication—and always dependable—helps this machine work to greater precision tolerances than ever before thought possible in a forging press. Lubrication is by Farval—a total of 205 bearings served by four systems—three heavy-duty automatics for the lubrication of the press proper and one manual for the lubrication of the controls.

Farval Centralized Lubrication Systems are serving millions of bearings in all kinds of industrial equipment. Farval is ready to serve you, too. Call the Farval representative near you, or write us for Bulletin 26-R. The Farval Corporation, 3279 East 80th St., Cleveland 4, Ohio.

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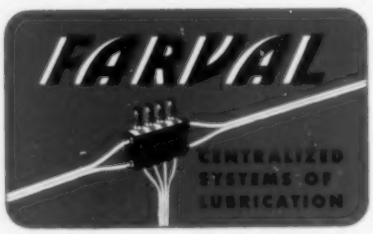
KEYS TO ADEQUATE LUBRICATION—
Wherever you see a Farval central pumping station, dual lubricant lines, and valve manifolds, you know a machine is being properly lubricated.

Three Farval heavy-duty automatic pumping stations that lubricate "Major" are to be seen at lower right.



DESIGNING WITH ALUMINUM

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series supplied on request. Address: Advertising Dept., Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

NO. 21

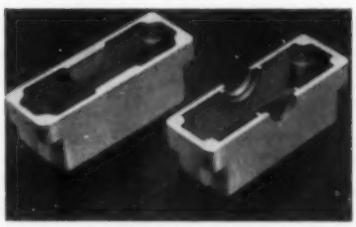
DESIGNING FOR ALUMINUM PLASTER MOLD CASTING

The process of casting molten metal in shapes closely approximating final desired form is one of the oldest methods of reducing production costs. In recent years, the ancient art of sand casting has been supplemented by new molding procedures, each with its special characteristics and qualifications. One of these is "plaster mold" casting.

By this method, parts may be cast with the complexity, dimensional accuracy and surface fineness of die castings, but without the extensive tooling required for die casting.

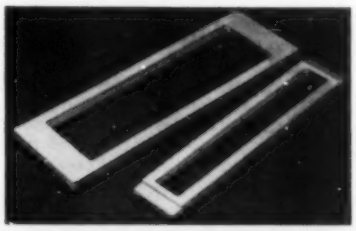
Here are the most noteworthy advantages of plaster mold casting:

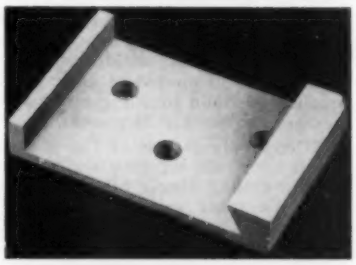
1. Fine details, with surface finishes in the range of 50 to 60 rms may be cast, with dimensional accuracy at .005" for the first inch, plus .001" for each additional inch.
2. Sections as thin as 1/32" may be cast, as may holes for tapping, mating surfaces, etc.
3. Uniform grain size and low porosity afford good structural characteristics.
4. Porosity of the plaster minimizes defects from gas entrapment.
5. Over-all cost savings result from reduction or elimination of finish machining and foundry sand control. Much of the process is easy to mechanize.
6. Set-up time is moderate for high-volume production of uniform, low rejection rate parts, with very low scrap loss.

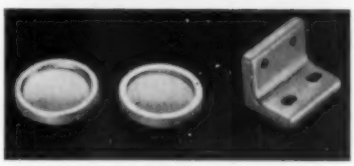


Housing for hydraulic control equipment is a plaster mold casting in aluminum. Note accurately formed bearing seat in the plaster mold casting (right) as compared with the sand cast piece it replaces. Also, wall sections are thinner, more uniform and more dense.

Many remarkable records in improved service and cost have been set by plaster mold castings. In one example of converting a two-piece sand cast photographic accessory to a single-piece plaster mold product, unit cost was cut by more than 90% through simplified design and reduced machining.







This group of aluminum plaster mold castings is used in spectographic instruments. Ability to obtain close tolerance on flatness and good metallurgical structure are reasons for using these castings.

In another instance, which involved the bed plate of a precise measuring instrument requiring guideways of almost optical flatness, plaster mold casting was attempted because of the inordinate rejection rate from warpage in machining sand castings. With the plaster cast plate, machining was reduced to a light surface cut. This gave accuracy in flatness and parallel of .001" across 18", and cut rejection from all sources to less than 5%.

Comparable achievements have been recorded by many different parts and accessories producers:

- The aircraft and automotive industries consume great quantities of plaster cast cylinder heads, control components, hydraulic system parts, bearing retainers and other fittings.
- Standard tools and hardware items for railroad applications commonly are plaster mold cast, with great uniformity and low cost.
- The electric industries make use of springs, couplings, connectors, levers, sparkless tools, appliance parts, gears, sprockets, clutches, valve members and similar accessories produced by plaster mold casting.
- Ornaments, locks, radar components, model train parts, plumbing supplies and surgical instruments are further examples of plaster molding versatility.

The process of preparing plaster casting molds is essentially the same as for sand casting. A master pattern, or model of the aluminum part, is made with whatever accuracy the finished casting must reflect. For high-volume production several master patterns may be used.

As in sand casting, the appropriately gated and vented pattern may be made in several pieces, as required for extraction from the flask, and may include various cores and inserts. The mold, however, is made in a specially designed casting plaster rather than in sand.

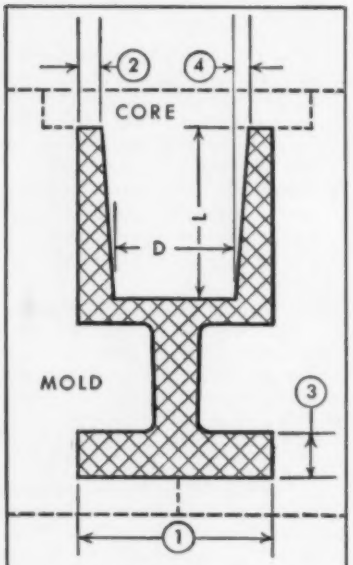
Also as in sand casting, the plaster mold is used only once, being broken during removal of its casting. In some applications, very satisfactory large castings of aluminum are obtained by composite molds of sand and plaster, using the plaster for those portions requiring high accuracy and smooth finish.

In preparing plaster molds, the mixture of water and special plaster is whipped in a power mixer so as to entrain tiny interconnected air bubbles in the slurry. This condition affords the high permeability by which gas entrapment is avoided. Surface fineness of aluminum castings is improved in proportion to the thoroughness of air-mixing. During this process, the volume of plaster slurry may increase by 50% to 100%.

When the poured plaster has taken its initial set, the pattern components are removed. After hardening, the mold is baked at 250° to 300° F. to insure thorough drying. Gas from residual moisture may cause undue casting porosity and other defects.

Pouring of metal usually is by the gravity method. Care in avoiding spattering and turbulence results in superior castings. Another quality assurance is the low cooling rate in the plaster enclosure, which permits relief of internal stresses and formation of a uniform grain.

The solidified casting is taken from its mold by a simple shake-out technique similar to that for sand castings.



Available Tolerances

1. Across parting line, plus or minus .005" for first inch or fraction. Add .001" for each additional inch.
2. Between any two points generated by the mold and a core, same tolerances as in case 1.
3. Between points in same part of mold, .003" for first inch or fraction. Add .001" for each additional inch.
4. Draft of 2° is typical. Zero draft often is possible.
5. Maximum L/D=5. That is, maximum diameter of core supported at one end should not exceed 5 times the core length.

A simple, plaster-molded aluminum section is illustrated above, with notes on typical coring and expectable accuracy. These statistics represent the standard findings of several major plaster mold casting producers. Even greater accuracy may be attained by adjusting of pattern equipment after observation of prototype castings.

The plaster also may be removed cleanly and inexpensively by high-pressure water jets.

In some aspects, a much greater degree of design latitude is possible with plaster-molded parts than with sand castings. For example, draft angles may be smaller because of the denser and more homogeneous mold material. The typical range of draft allowance is 0° to 2°, with an average of about ½°. These mold qualities also allow use of sharper edges and smaller fillet radii than are possible with sand castings.

The comparatively low cooling rate prevents concentrations of stress at these abrupt changes in contour.

It has been found that under conditions of high-volume production, the efficiency of plaster molding is most conspicuous in aluminum castings of small or medium size, in the range of perhaps ¼ pound to 15 pounds.

Strength limitations of the plaster molds affect the accuracy and the rejection rate of larger pieces, except those of simple form and minimum coring. Smaller parts, on the other hand, may entail an uneconomic level of unit-handling.

TABLE 1

PROPERTIES OF ALUMINUM PLASTER MOLD CASTING ALLOYS

Alloy No.	*Tensile Strength psi	*Yield Strength psi	Feeding Ability	Pressure Tightness	Machinability	Weldability	Corrosion Resistance	Elongation % in 2"
195	40,000	30,000	G	G	E	F	G	2.0
355	38,000	36,000	E	E	E	VG	VG	0.5
356	34,000	30,000	E	E	E	VG	E	2.0

Ratings: E, excellent; VG, very good; G, good; F, fair.

* In heat treated condition

Physical properties offered by plaster molded aluminum castings are shown in Table 1, where several of the excellent casting alloys available from Kaiser Aluminum are tabulated. A notable feature of the plaster molding process is that these metal qualities are highly uniform throughout the casting.

Many metal products now manufactured by more expensive, less satisfactory processes are ideal for production in aluminum by the plaster mold casting method. The investment in equipment usually is moderate, and the required materials are available in quantity. The wide design experience of Kaiser Aluminum engineers is available, upon request and without obligation, to any manufacturer interested in this progressive fabrication process.

For immediate attention to your request for this advisory service, or for more detailed information, contact the Kaiser Aluminum sales office or distributor listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California.

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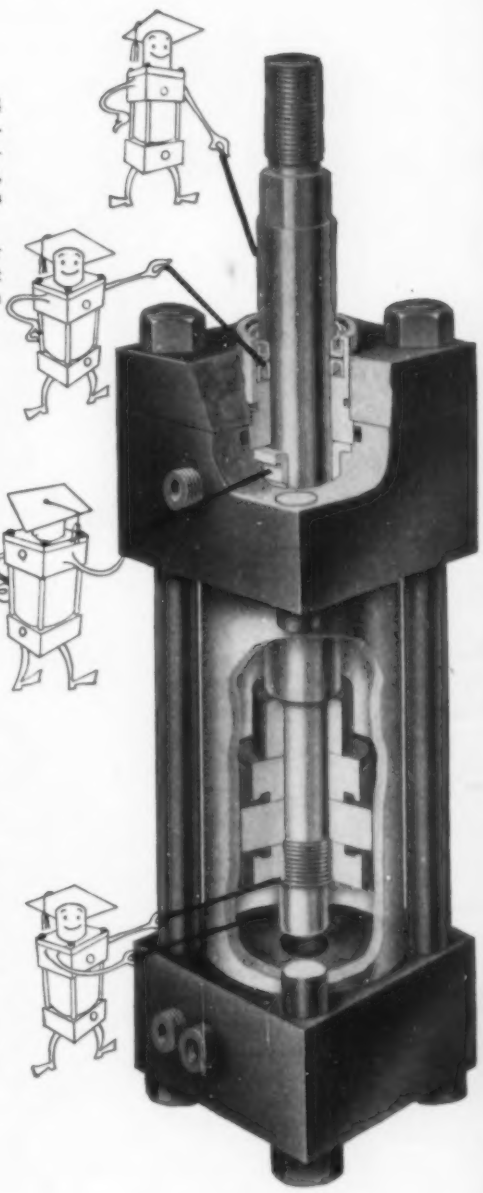
Cylinder heads, caps, mountings, pistons, followers, tie rods, and the unplated portions of the piston rods have this finish ***at no extra cost on all Miller cylinders.*** (This finish not recommended for water service)



NOTE. On all Miller Hydraulic Piston Seals: Leather Cup Seals are *standard*, Piston Ring Seals are optional *at no extra cost*, and "Teflon" Cup Seals are available *at extra cost.*

You may wish to route this entire page to the proper department in your company, by using this handy form. Additional copies on request. →

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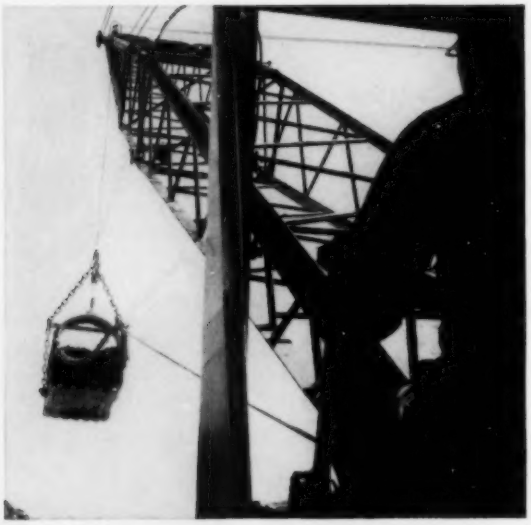
COUNTERBALANCE CYLINDERS

HOW USS "T-1" STEEL IMPROVES

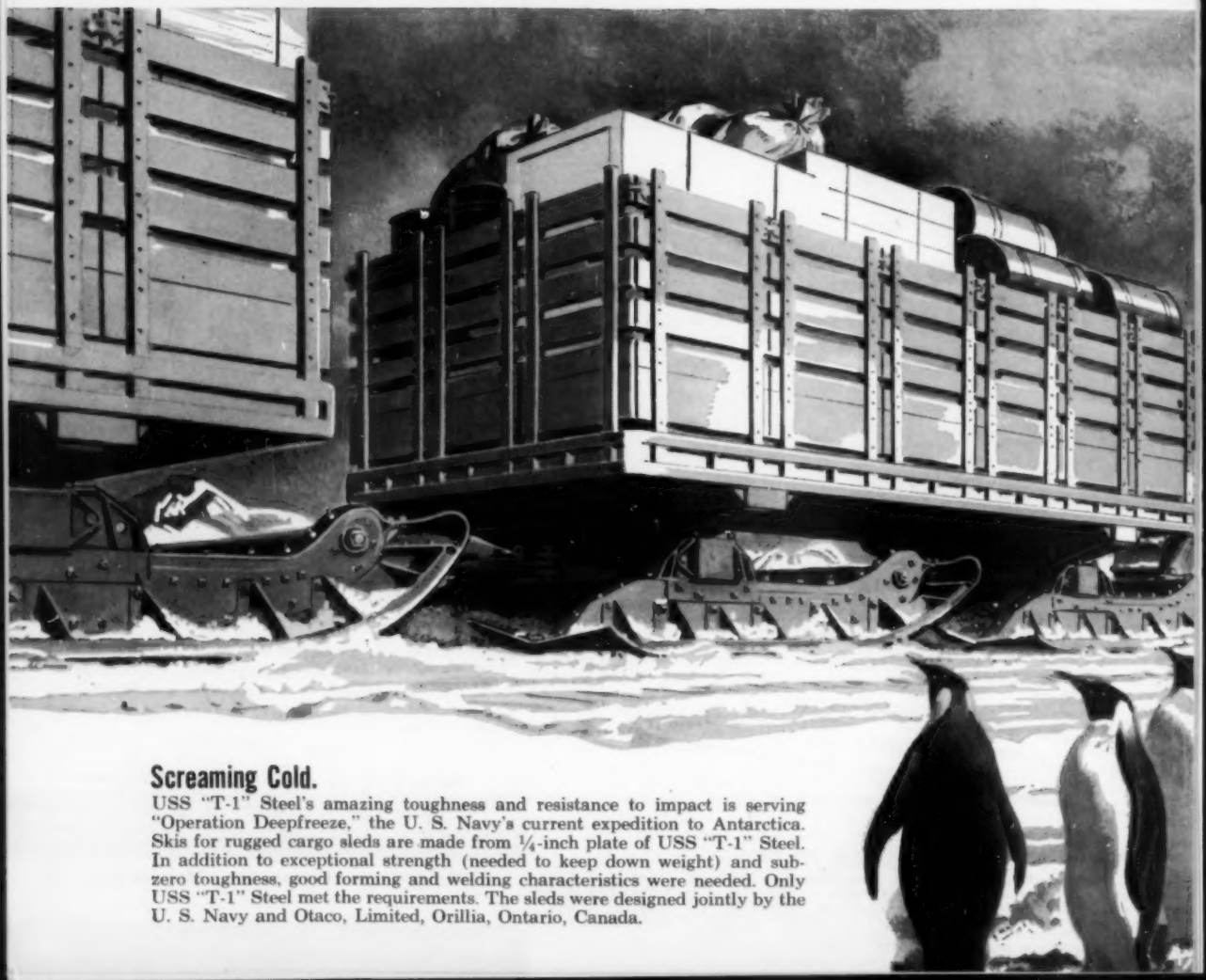


Repair Reduces Downtime.

In this coal stripping operation, time costs more than any other item; and *lost* time, caused by breakage and wear of power shovel parts, was costing far too much. So the owner, Putnam & Greene, Inc., Philipsburg, Pennsylvania, started using USS "T-1" Steel for repair work. As a result, size and weight of parts have been reduced, while durability has been improved substantially. What's more, USS "T-1" Steel's good weldability speeds repair work.

28 Million Pounds of Wet, Abrasive Coal

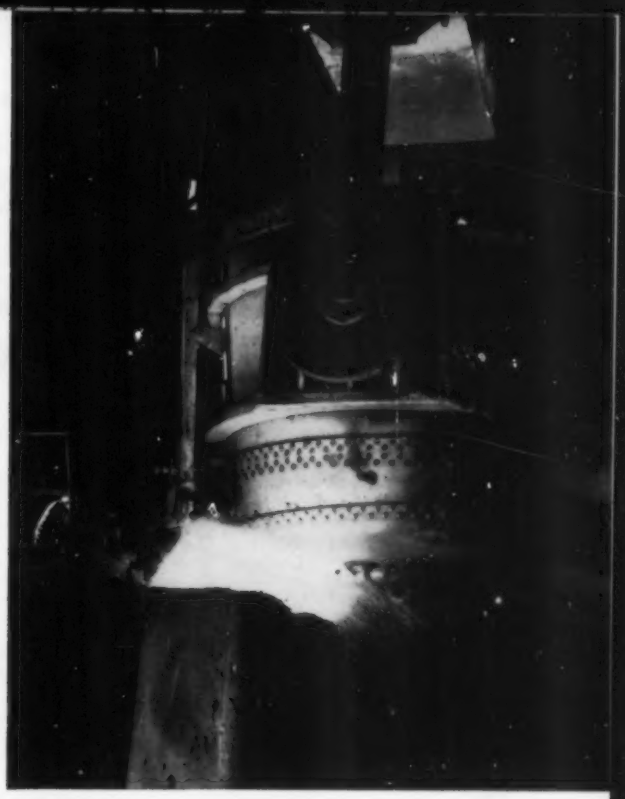
are handled each day at this steam-electric generating station. And USS "T-1" Steel is being used at points of severe wear in coal chutes and hoppers, pulverizer feed pipes and exhaust pipes, and for liners of ash collectors. USS "T-1" Steel's durability under impact and impact abrasion, its great tensile strength and its good weldability are often essential in rugged coal handling equipment. USS "T-1" Steel can add service life and cut repair and maintenance costs.



Screaming Cold.

USS "T-1" Steel's amazing toughness and resistance to impact is serving "Operation Deepfreeze," the U. S. Navy's current expedition to Antarctica. Skis for rugged cargo sleds are made from ¼-inch plate of USS "T-1" Steel. In addition to exceptional strength (needed to keep down weight) and subzero toughness, good forming and welding characteristics were needed. Only USS "T-1" Steel met the requirements. The sleds were designed jointly by the U. S. Navy and Otaco, Limited, Orillia, Ontario, Canada.

THESE PRODUCTS:



Sizzling Hot.
By redesigning with USS "T-1" Steel, crane hooks for 250-ton ladles at U. S. Steel's Edgar Thomson Works were reduced in thickness from 8½ inches to 6 inches. The resulting weight saving of 3 tons permits an increase in actual crane capacity. The ladles, too, were redesigned with USS "T-1" Steel. All told, the weight saved adds 20 net tons to the capacity of each new ladle.

HOW IT CAN HELP YOU

USS "T-1" Steel, with its high minimum yield strength of 90,000 psi and its minimum tensile strength of 105,000 psi, can help you design or build lighter-weight equipment that will last longer. Its unusual toughness can help you design or build equipment capable of taking heavy impact and abuse at sub-zero temperatures. Its excellent weldability can help you cut the cost of fabricating highly stressed parts, and to reduce repair and maintenance expense. Its good creep rupture strength can help you put more durability in equipment that operates at temperatures as high as 900 degrees F.

Somewhere in your operation, versatile USS "T-1" Steel can help you. Write, wire, or phone United States Steel, Room 5426, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION
WAREHOUSE DISTRIBUTORS, COAST-TO-COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T1" CONSTRUCTIONAL ALLOY STEEL

USS

SEE The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL

there is something NEW in motors!

Sutco MINI-LAP*

PERMANENT SPLIT-CAPACITOR MOTOR

Built to Your Exact Specifications

Whatever your requirements in permanent split-capacitor or shaded-pole motors – Sutco can meet them.

Mini-Lap® Permanent Split-Capacitor Motors are built precisely to your specifications in ratings through ⅓ H. P. with highest efficiency and power factor.

Sutco Shaded-Pole Motors are specifically designed to fit YOUR requirements. Ratings are:

- **2-Pole – up to 1/60 H. P.**
- **4-Pole – up to 1/8 H. P.**
- **6-Pole – up to 1/4 H. P.**

Refer your needs in motors to our staff of competent sales and product engineers for most economical recommendations.

Now, Sutco presents an entirely new concept in permanent split-capacitor motor design – the MINI-LAP.* Minimum overlap of expensive copper windings... fully automated winding of the stator reduce motor costs to a minimum – and produce higher efficiency.
Positive mechanical spacing between main and auxiliary windings of the 6-pole Mini-Lap® provide added protection against electrical breakdown. Steel stator ring supports rugged die-cast aluminum end heads.

*Patent Pending

WRITE TO SUTCO; ORIGINAL EQUIPMENT DIVISION

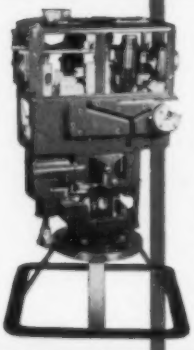
Sutco ORIGINAL EQUIPMENT

THE O. A. SUTTON CORPORATION, INC. • WICHITA, KANSAS

8-2

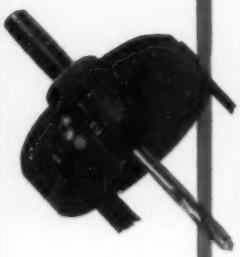
5 practical ways to "streamline"

...without sacrificing fastening strength



1. Counterbored holes are the simplest approach to flush surfaces using standard socket cap screws. The advantage of specifying genuine Allen O Head Cap Screws is the greater strength of Allenoy steel... you can use smaller sizes for closer spacing and reduced weight. Call on Allen, too, for *very large* socket-head, precision cap screws — up to 2½ inch diameter.

2. Countersinking enables you to get absolutely smooth external surfaces using Allen O Flat Head Cap Screws. Allen O Cap Screws feature the exclusive Leader Point which makes screw starting easier and guards against thread damage.



3. Button Head Cap Screws produce snag-free unbroken surfaces where countersinking is impractical. Button-head hex sockets are necessarily shallow. In genuine Allen O Button-Head Cap Screws, sockets are cold forged without broaching, in extra strength Allenoy steel... essential protection against stripping the sockets under high torque pressure.

4. A ready made hole tapped in forged steel solves many a design problem. It's called the Allenut. It can be anchored in soft material to assure durable threading, or recessed to permit tightening with an Allen Hex Key.

5. Bright finish, or rust and corrosion resistance call for Allen O Stainless Steel Cap Screws. They are standard stocked items (both NF & NC threads) readily available in a wide range of sizes from Allen Distributors.

YOUR ALLEN DISTRIBUTOR can give you practical help and swift service. For complete information on any technical fastening problem, write our engineering department direct.

ALLEN HEAD

ALLEN

MANUFACTURING COMPANY

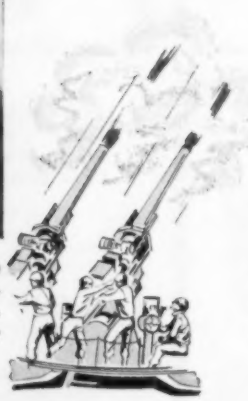
Hartford 2, Connecticut, U.S.A.

fast!

...680 units per minute!

Actual action photo taken by stroboflash

"Gunner" Don Lang, "zeros in" on top profits for our customers with his high-speed Flexopress ripping out machine-gun bursts of 680 component parts per minute.

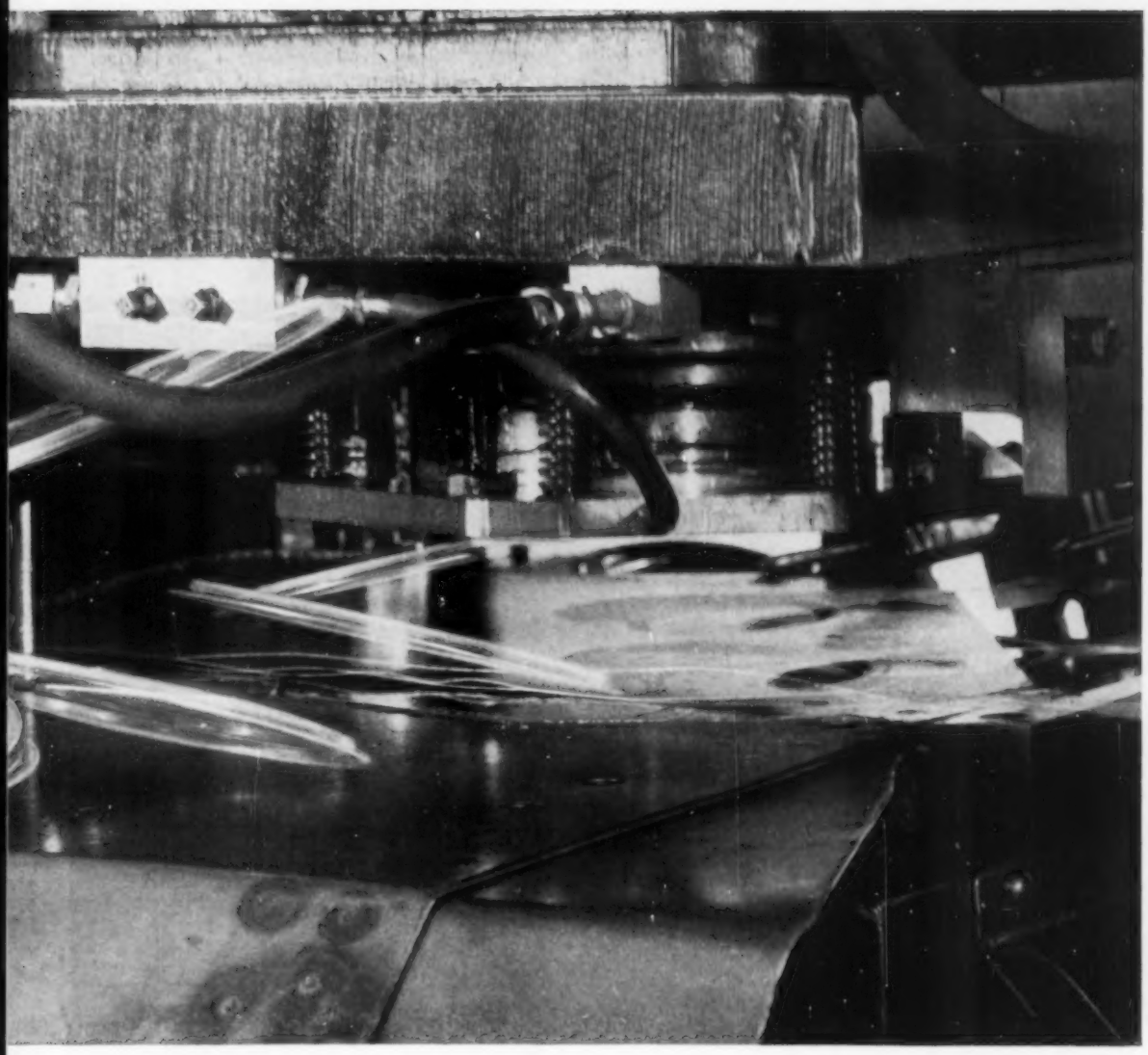


automatic

Speed plus accuracy equals low-cost volume.

That's the formula for success in component part production *and* purchasing, because you only benefit from quantity buying when you have a source that's set up for *quantity* and *quality* production.

We have high-speed equipment unduplicated anywhere in America, that can



weapon...peacetime style!

be tooled to your job, if your job can absorb real quantity runs. The resultant saving is what we call "pushbutton profit" for you, the buyer. It comes from *automatic* operation, making thousands of units every hour of the run.

If "pushbutton profits" appeal to you and pushbutton methods can be applied to your job, send us your inquiries, for prompt quotation.

ALUMINUM GOODS MANUFACTURING CO.
MANITOWOC, WISCONSIN
FIFTH AVENUE BLDG., NEW YORK 10 • MERCHANDISE MART, CHICAGO 54

The ring of quality

Colorful, low-cost sidewall rings that can be quickly installed on tires are now contributing to the luxury-look of today's new cars. They're inexpensive, stay brilliant for life, wash bright in seconds, out-last tires. A product of The Bearfoot Sole Co., Wadsworth, Ohio, these rings are available in a variety of colors or in white. They're made of Enjay Butyl Rubber because no other rubber tested could equal its performance in severe laboratory and road tests. The Enjay Butyl label on the Flex-A-Wall® carton assures the buyer of outstanding quality.

Find out for yourself the many technical advantages of Enjay Butyl—the rubber that is outperforming natural and other types of rubber in a wide variety of industrial and consumer applications. For full information, and for technical assistance in the use of Enjay Butyl, write, wire or phone the Enjay Company.

ENJAY BUTYL

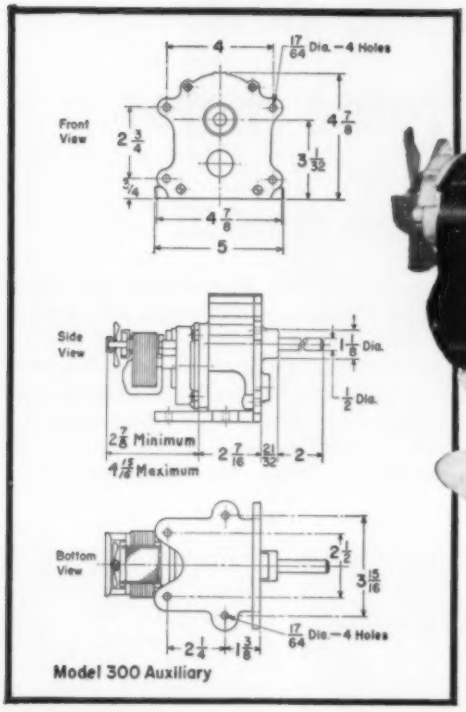
ENJAY *Pioneer in Petrochemicals*

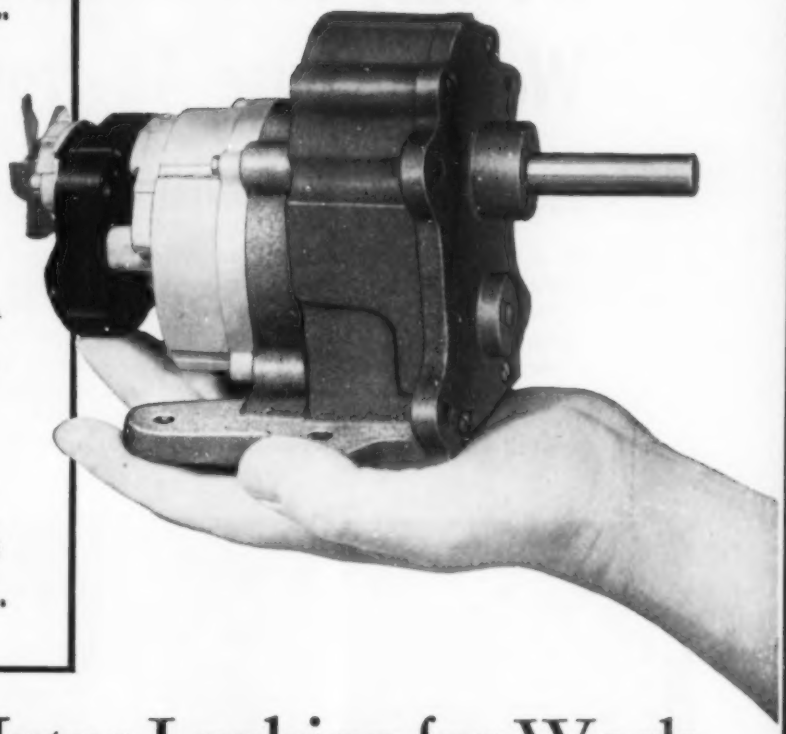
ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Other offices: Akron • Boston • Chicago • Los Angeles • Tulsa

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

POWER UNDER CONTROL





Here's a Motor Looking for Work

The newest in the line of Merkle-Korff fhp geared motors is the model #300 shown above. This unit, in continuous duty service, will deliver up to 300 lb. in. torque, yet it fits in the palm of your hand. The motor is ideally suited for applications requiring the operation of heavy cams, cranks or gears mounted directly on the motor shaft.

A typical torque table is shown below. This table shows no-load speeds for uni-directional shaded pole induction motors. The loads are the maximum under which the motor will start and operate continuously without over-load. The range of speeds shown are representative of those most commonly used. If the maximum rated torque is required at speeds greater than shown, modifications can usually be made, or the unit can be furnished at speeds as low as 1 RPH or slower.

This model #300 is only one of a long and varied line of Merkle-Korff fhp geared motors. They range in speed from 800 RPM down to any fractional RPM required. Merkle-Korff motors can be furnished either with induction shaded pole motors, or with synchronous, reversing, series, or shunt wound motors. These motors are furnished in a wide range of horse power ratings depending upon the output shaft torque requirements.

Merkle-Korff engineers will assist your design staff in specifying the unit best suited to your requirements.

TORQUE TABLE
MODEL 300

rpm	stator thickness		
	$\frac{5}{16}$"	$\frac{13}{16}$"	1½"
10	25 lb. in.	33 lb. in.	60 lb. in.
8	30	40	75
6	42	54	100
5	50	65	120
4	62	80	150
3½	70	92	170
3	80	108	200
2½	100	130	240
2	125	162	300
1½	166	216	300
1	250	300	"
½	300	"	"

MERKLE-KORFF GEAR CO.

219 NORTH MORGAN STREET • CHICAGO 7 • ILLINOIS

EDWIN M. BOND
Box 333, Rumson, N. J.

RALPH D. EARNEST ASSOCIATES
12818 Puritan Ave., Detroit 27, Mich.

HENRY F. KAELIN
1412 S. Los Angeles St., Los Angeles 14, Calif.

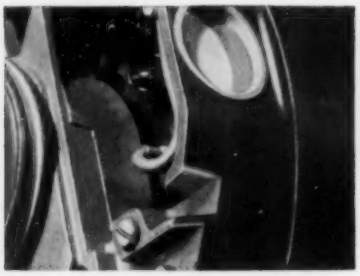
It's easy to handle the new Westinghouse 48-frame motor

These five big mechanical advantages prove it!

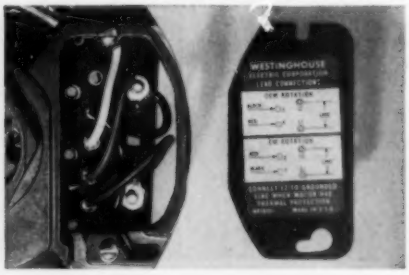
Up to 35 pounds of pull will not disconnect the line cord on this new Westinghouse 48-frame motor. A built-in strain relief, one of this motor's many mechanical features, was designed with you in mind.

The mechanical advantages you get with the new Westinghouse 48-frame simplify your product design problems. They help speed up your assembly—make it easier and less costly. And they assure you of the permanent dependability you need and require to help make *your* product better—more salable.

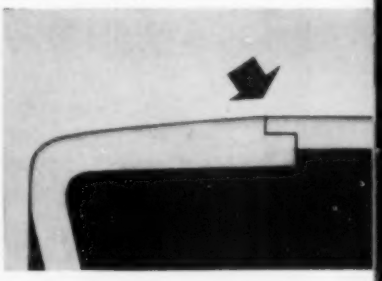
For more information on the mechanical and other advantages of the new, lighter, more compact Westinghouse 48-frame motor, contact your nearby Westinghouse sales engineer. Or, write for descriptive bulletin DB-2801 to Westinghouse Electric Corporation, P. O. Box 566, Lima, Ohio. J-03030



POSITIVE CONNECTIONS are assured with the Westinghouse built-in strain relief for line cords. Easy-to-get-at knockout permits quick threading of conduit into spacious terminal box.



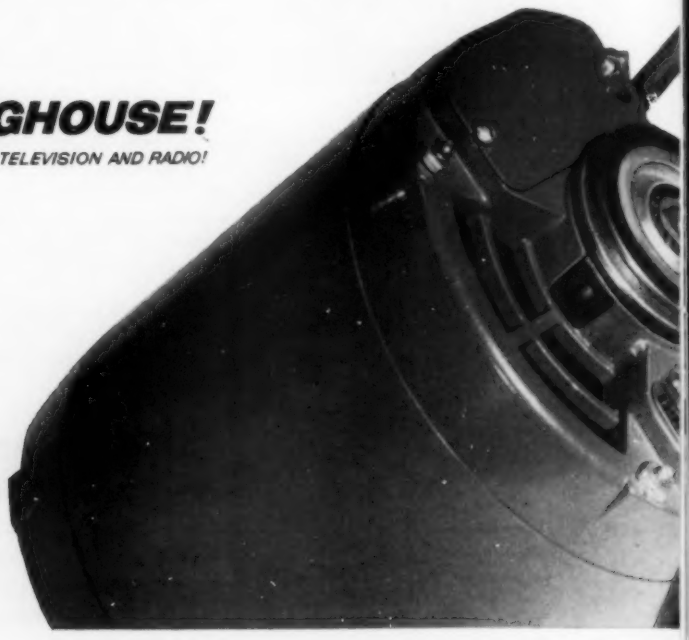
SIMPLE CHANGE of voltage and rotation is possible with easily accessible plugs on a modern terminal board. Motor's versatility materially reduces stocking requirements.



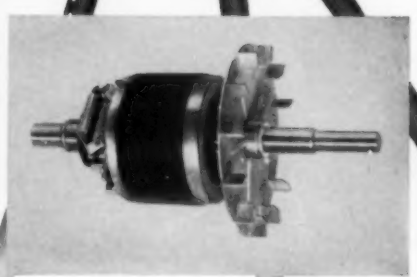
HEAVY FRAME with machined fit for end brackets assures positive alignment. Absence of "Swiss-cheese" vents in solid frame protects windings against liquids or dirt.

WATCH WESTINGHOUSE!

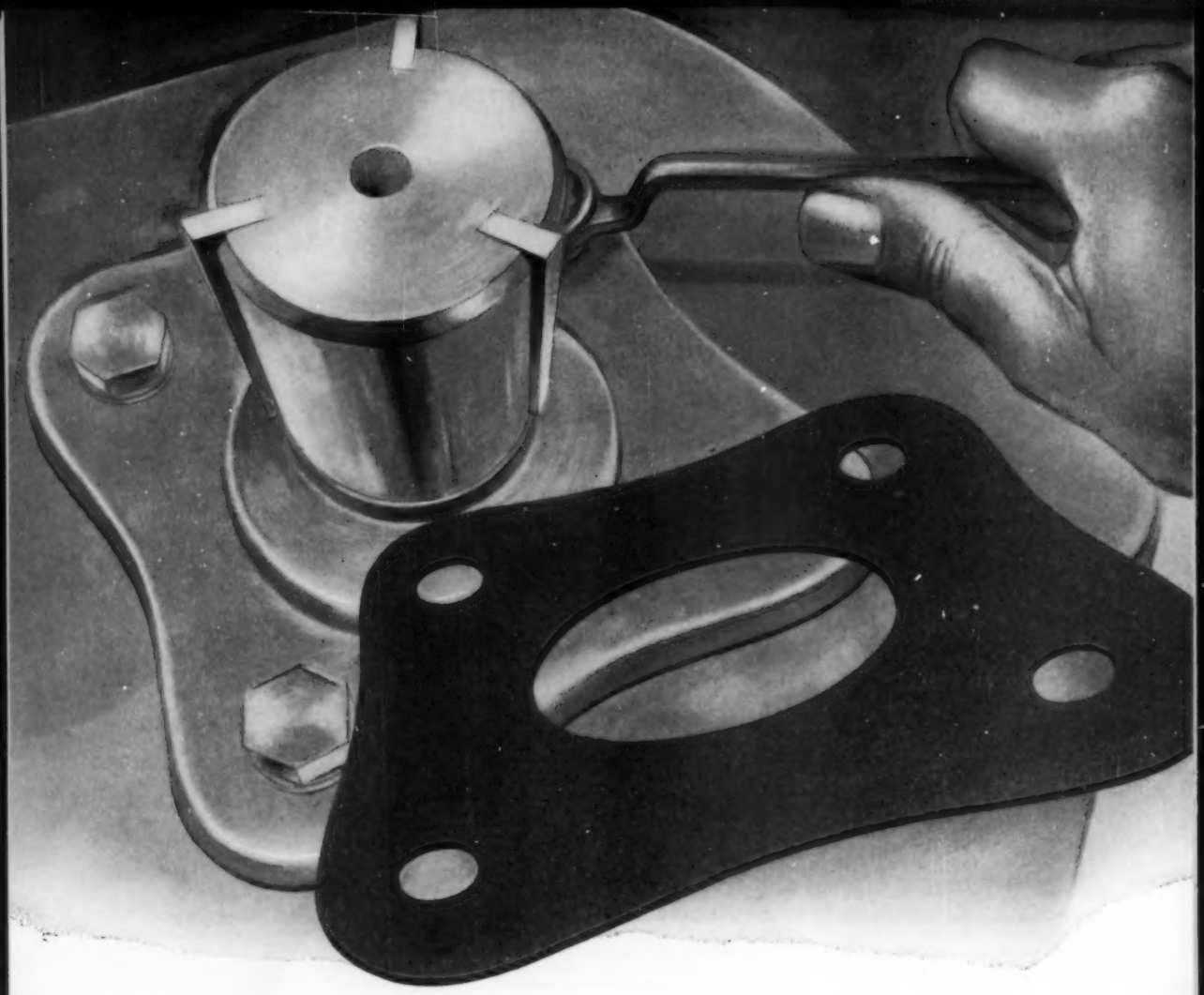
COVER THE PRESIDENTIAL CAMPAIGN ON CBS TELEVISION AND RADIO!



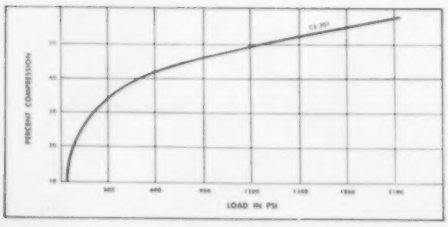
WELDED FOOT provides an absolutely rigid mounting—assures accurate control of shaft height. Rigid or resilient mounted, these new motors can be operated in any position.



CONTROLLED CONCENTRICITY through use of centerless ground shaft and dynamically balanced, aluminum die-cast, skewed rotor assures even torque and extra-quiet operation.



Accopac® fiber gasket seals tightly under stamped flanges



HIGH COMPRESSIBILITY of CS-301 Accopac is shown by load-compression curve. With light metal flanges, this compressibility allows gaskets to conform to surface irregularities and form a tight seal without distorting flange.

Armstrong CS-301 Accopac® is a highly compressible fiber gasket material that forms a tight seal against fluids even under the low bolting pressures available with stamped flanges.

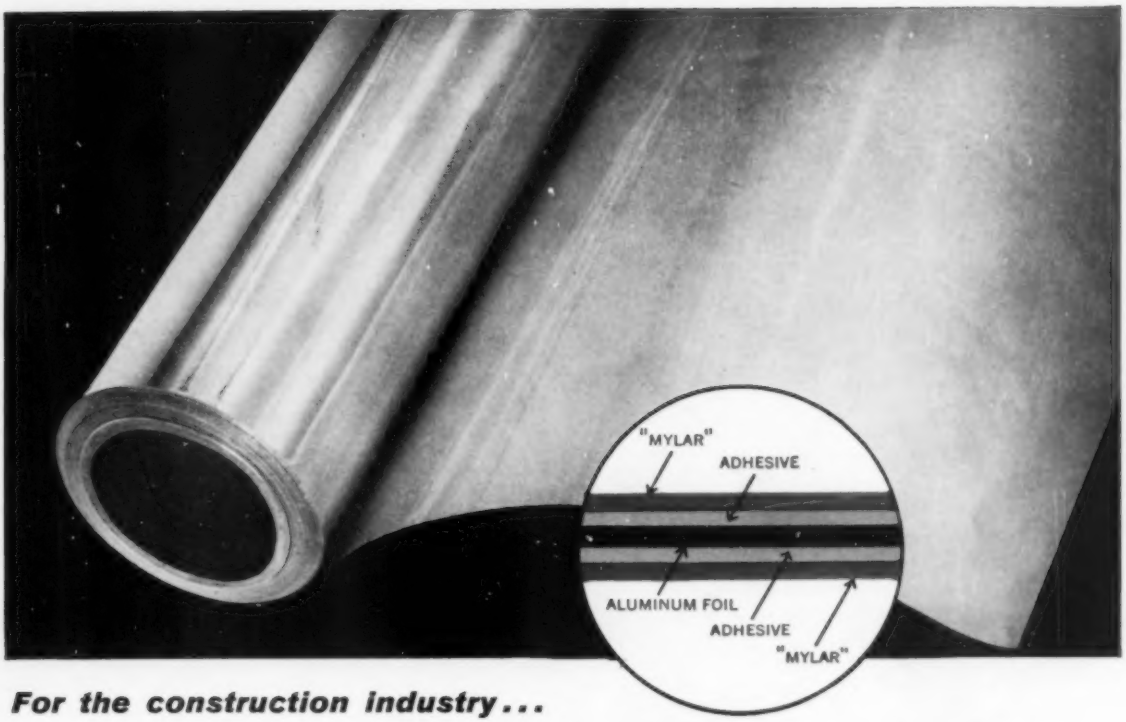
CS-301 is made by a patented beater saturation process that locks cellulose fibers and cork in a non-extractable latex binder. The cork—thousands of tiny, springy particles—gives CS-301 its high, uniform compressibility. And although CS-301 is unusually compressible, it retains bolt torque well at flange pressures under 2000 psi at temperatures up to 200°F.

CS-301 is a dependable seal for water, air, most gases, and many commonly used solvents. It is now being used for many applications in automobiles, tractors, appliances, and industrial equipment.

For more information about Armstrong CS-301 Accopac, write Armstrong Cork Company, 7010 Irvin Street, Lancaster, Pennsylvania.

Armstrong ACCOPAC

. . . used wherever performance counts



For the construction industry...

A NEW BARRIER ARMORED WITH "MYLAR" REDUCES MOISTURE PERMEABILITY TO ZERO!

Food Fair Company's new frozen-food warehouse in Linden, N. J., uses vapor barrier made of Du Pont "Mylar" and foil. The barrier is easily applied and sealed tightly with pressure-sensitive tape of the same material. Men shown walking on the vapor barrier illustrate the extra toughness and abrasion resistance of this lamination with "Mylar".

Thanks to a new material made of Du Pont "Mylar"* polyester film and aluminum foil, industrial constructors have a completely new moisture-barrier material for more effective control of humidity. Already, this new material is being used in warehouses for frozen-food storage, special rooms for the operation of extra-sensitive electronic equipment and storage facilities for military equipment.

This new laminate with "Mylar" is strong yet light in weight — there's no need for extra support frequently used for heavier moisture barriers. Since this flexible material comes in roll form, it's much easier to install than rigid barriers. When slit into tape widths with a pressure-sensitive adhesive, this same laminate provides an effective seal to join the sheet together. Most important, this laminate of "Mylar" and foil provides *zero permeability* to moisture vapor!

Here is another example of how Du Pont "Mylar", used alone or in combination with other materials, is improving old products and helping create new ones. For more information on properties, applications and types of "Mylar" available, send in the coupon below. Be sure to indicate specific application you have in mind.

DU PONT

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

***"MYLAR** is Du Pont's registered trademark for its brand of polyester film.*

In Canada, "Mylar" is sold by the Du Pont Company of Canada Limited, Films Div., P. O. Box 660, Montreal, Quebec.

DU PONT
MYLAR®
POLYESTER FILM

E. I. du Pont de Nemours & Co. (Inc.)
Film Dept., Room P-10, Nemours Bldg., Wilmington 98, Delaware

☐ Please send information on properties, applications and types of "Mylar" polyester film available (MB-4).

☐ Please send information on moisture-barrier material made with "Mylar".

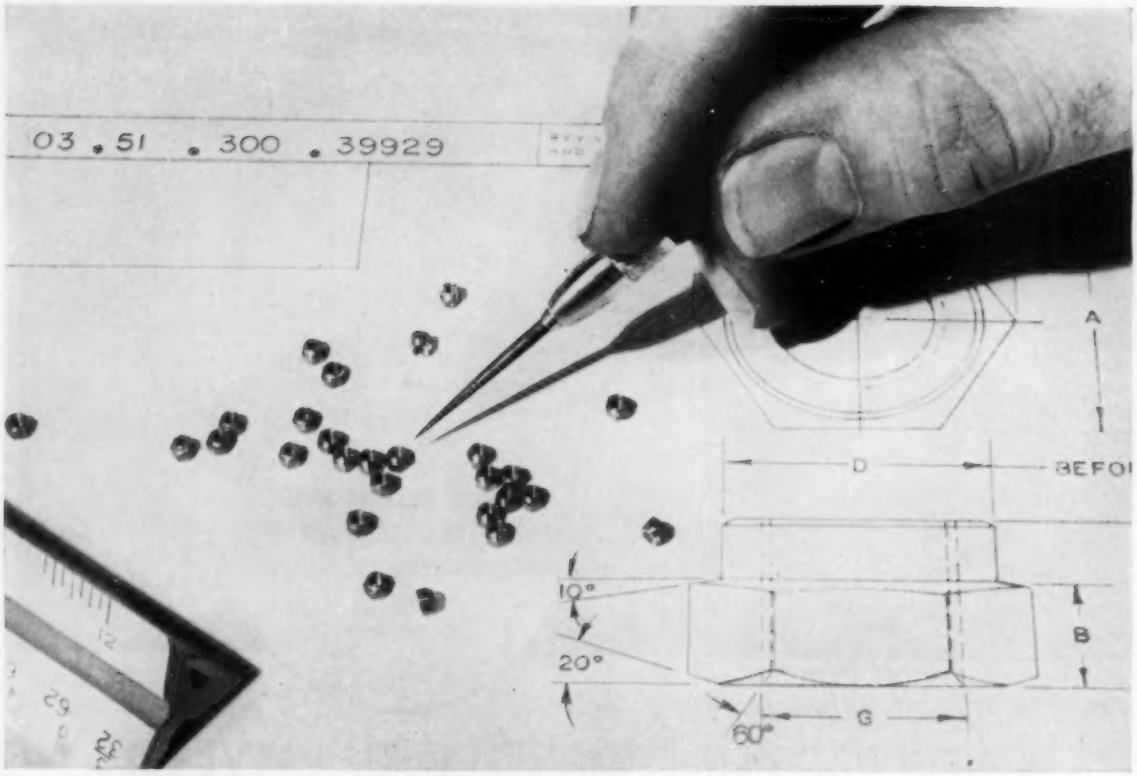
APPLICATION_____

NAME_____

FIRM_____

ADDRESS_____

CITY_____ STATE_____



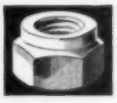
FLEXLOC MICROSIZE locknuts meet designers' needs for tiny precision nuts that retain strength and holding power in the smallest assemblies—servomechanisms, electronic and electrical equipment, all miniature devices.

New FLEXLOC Microsize Locknuts

Now available in Alloy Steel, Stainless Steel, Brass and Aluminum for lighter, more compact designs

SIZE	Across Flats		Shoulder Height		Across Corners	Height +.000 −.003
	MAX.	MIN.	MAX.	MIN.	MIN.	
0-80 NF-3B	.111	.107	.047	.042	.123	.075
1-64 NC-3B	.127	.123	.0635	.0585	.141	.090
1-72 NF-3B	.127	.123	.0635	.0585	.141	.090
2-56 NC-3B	.158	.153	.068	.063	.176	.105
2-64 NF-3B	.158	.153	.068	.063	.176	.105
3-48 NC-3B	.190	.183	.071	.066	.210	.120
3-56 NF-3B	.190	.183	.071	.066	.210	.120
4-40 NC-3B	.190	.183	.072	.067	.210	.120
4-48 NF-3B	.190	.183	.072	.067	.210	.120

SPECIFICATIONS: Available in brass (plain or cadmium plated) and aluminum (plain or chemically treated), for temperatures to 250°F; alloy steel, 18-8 stainless, for temperatures to 550°F.



New FLEXLOC Microsize locknuts are smaller and lighter than regular FLEXLOCS of the same nominal diameter. Wrenches of smaller size are used to install them. Mating joints or flanges can be designed smaller—with no loss in strength or convenience of assembly.

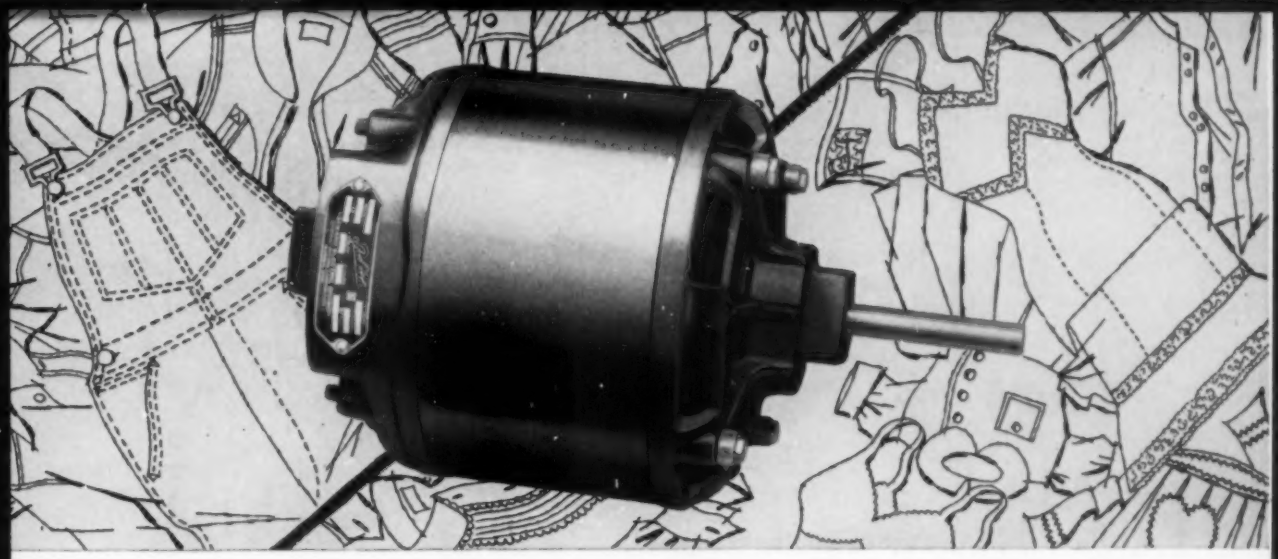
Microsize FLEXLOCS have all the advantages of larger FLEXLOCS. One-piece, all-metal construction—nothing to put together, come apart, lose or forget. Use them as lock or stop nuts—they stay put anywhere on a threaded member as soon as the locking threads are fully engaged. Uniform locking torques insure accurate preloading. There are no nonmetallic inserts to pop out or deteriorate. Moisture, dryness, oil won't affect these Microsize FLEXLOCS. Just screw them on. They lock and stay locked. Vibration won't shake them loose.

For complete information on Microsize FLEXLOCS, consult your authorized SPS distributor. Or write STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

STANDARD PRESSED STEEL CO.

FLEXLOC® LOCKNUT DIVISION SPS

JENKINTOWN PENNSYLVANIA



PACKARD ELECTRIC / *NEW... custom-tailored washing machine motor*

FHP MOTORS / *Provides power for two washing speeds... electrically!*

It's an old idea based on need. Make the agitator speed variable. Then, both light and heavy clothes could be thoroughly washed without harming fabrics.

There were no two-speed appliance motors available with enough power at both speeds. Mechanical means, such as gears, belts and pulleys, clutches, etc., cost too much, took up too much space, made too much noise and caused too many maintenance problems.

A Packard Electric motor engineering team was first to solve the problem with a compact, two-speed unit that had just the amount of speed, power and torque required. And washing machine manufacturers who worked out the solution with Packard Electric engineers have had a big competitive advantage ever since.

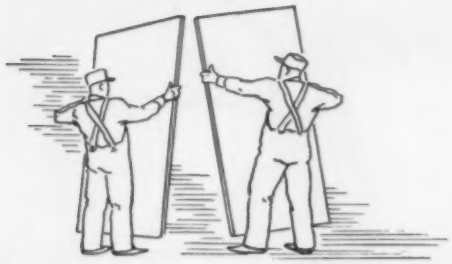
What's more, there are further savings in assembly when you buy Packard. That's because Packard will deliver a motor complete with special mountings and accessories to simplify your assembly procedures.

Packard Electric research and engineering teams have a long record of accomplishment in the custom-built motor field. And, even now, new ideas are on the boards to help our customers produce better, lower priced products for the appliances of tomorrow.

Packard Electric

Warren, Ohio GM GENERAL MOTORS

Division of General Motors



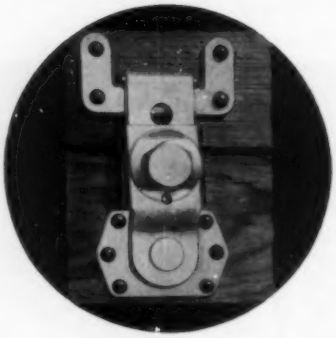
Have you a similar fastening problem?

How a strong structure can be designed for speedy and simple assembly with unskilled labor, no special tools...

The U. S. Air Force wanted a jet-aircraft hangar design that would be portable by air, yet strong; would assemble quickly; be interchangeable, and flexible enough for easy structure modification.

The answer lay in a panel structure using modular units. Armorply honeycomb panels faced with thin aluminum, developed by United States Plywood Corporation, provide lightness, strength, flexibility. Joining one panel to the other in the field with untrained help was a problem until Simmons Fastener developed LINK-LOCK, a simple latching device that operates with minimum wrench pressure on hex nut.

This fastening problem is being successfully met by combining the design ingenuity of No. 1 LINK-LOCK with the proved performance of honeycomb plywood panels.



No. 1 LINK-LOCK—like No. 2 LINK-LOCK—features simplicity, positive action, high strength.

No springs are used in No. 1 LINK-LOCK. Locking action is obtained by rotating a nut that moves a sliding latch in and out of position. Up to 1500-lb. pull-down pressure is available; the device carries up to 4000-lb. tension. No. 1 LINK-LOCKS provide for surface mounting, simplifying installation.

Where can you use it? When you need heavy fastening pressures, resistance to impact, operation in 70-below temperatures—and where ease of action, compactness, and low cost are important factors. Write for a No. 1 LINK-LOCK Data Sheet.

SIMMONS FASTENER CORPORATION
1751 No. Broadway, Albany 1, New York

Simmons

LINK-LOCK
QUICK-LOCK
SPRING-LOCK
ROTO-LOCK

FASTENERS THAT IMPROVE PRODUCTS AND REDUCE ASSEMBLY COSTS

there's a combination starter you KNOW is Safe!

Bulletin 712 Combination Starter consists of a standard Bulletin 709 across-the-line starter mounted in a cabinet with an A-B manual disconnect switch. Fuse clips are optional.

OPERATING LEVER CAN BE PADLOCKED IN "OFF" POSITION

You can use from one to three padlocks to lock this starter in the "off" position—or, for unusual applications, change it to permit padlocking in the "on" position.

TO OPEN COVER LEVER MUST BE IN "OFF" POSITION

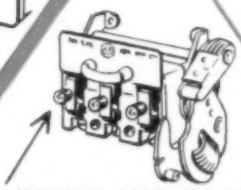
The disconnect switch lever is so interlocked that the cover of the cabinet cannot be opened until the disconnect switch is "open" and the starter is "dead."

COVER ITSELF CAN BE PADLOCKED

Provision for locking the cover to the base of the cabinet with a padlock eliminates all possibility of tampering with the mechanism.

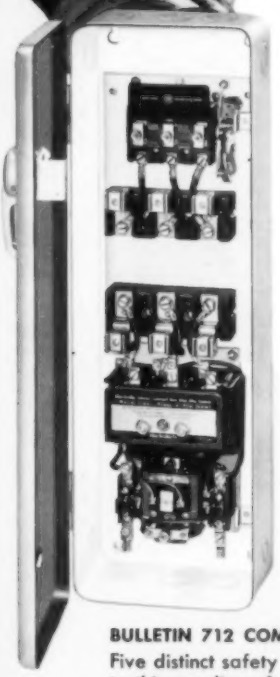
INSULATING SHIELD COVERS "LIVE" LINE TERMINALS

With the cover open, only the incoming line terminals are "alive"—and in Allen-Bradley Bulletin 712 starters, these are covered with an insulating shield.



MOVABLE CONTACTS ARE PLAINLY VISIBLE IN "OFF" POSITION

When in the "off" position, the movable disconnect switch contacts show above the arc hood in plain view. Welded or sticking contacts can be detected instantly—a reliable safety signal.



BULLETIN 712 COMBINATION STARTER

Five distinct safety features give "plus value" to this new line of Allen-Bradley Bulletin 712 Combination Starters. And—you also get the design simplicity and the many other advantages for which the Allen-Bradley solenoid starter has earned its "quality" reputation.

Available in NEMA Types 1, 4, 7, 9, and 12 enclosures, from 1 to 100 hp, 220v; 200 hp, 440-550v.

8-56-MR

A-B Quality

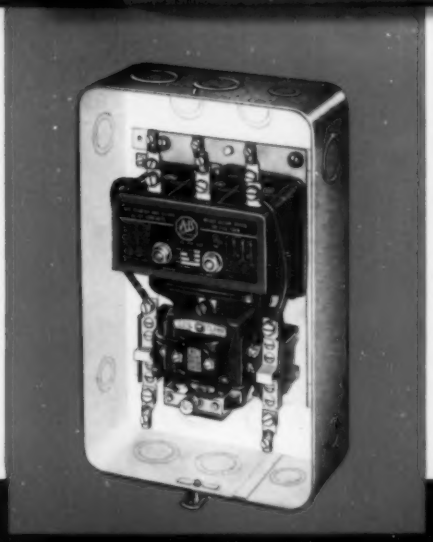
ALLEN-BRADLEY

MOTOR CONTROL

QUALITY

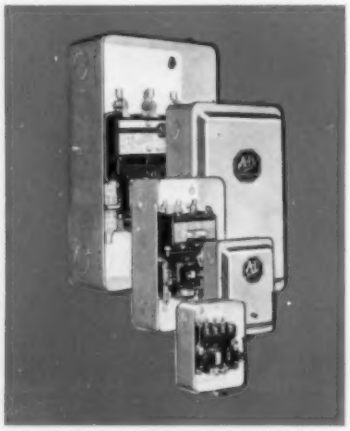
Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

This simple design remains "tops"



Only one moving part–

that's why it's good for millions of operations!



Shown above are five sizes of the Bulletin 709 across-the-line solenoid starters. Three larger sizes are also available with a maximum rating of 300 hp, 220 volts; 600 hp, 440-550 volts.

The solenoid plunger shown above is the only moving part in any Allen-Bradley solenoid starter. Its straight up-and-down action is practically frictionless. There are no pivots, pins, or hinges to stick and cause trouble. That's why you are assured of millions of trouble free operations.

All Allen-Bradley solenoid starters have double break, silver alloy contacts that never need service attention of any kind. You just install them and forget them. On more and more automatic production machines, where continuity of operation is a "must," Allen-Bradley motor starters are standard equipment. Try them on your tough jobs!

A-B Quality

ALLEN-BRADLEY
SOLENOID MOTOR CONTROL
QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

8-56-MR

FLEXIBLE TUBING FOR INDUSTRY

On air intakes, fuel lines, exhaust lines, Penflex Flexible Tubing has proved itself in plants across the nation. Rugged . . . tough . . . flexible Penflex Tubing is made to stand the most severe usage.

From ⅛" to 24" I.D. . . . bronze, galvanized or stainless steel Penflex makes all types and sizes of flexible metal tubing. Penflex "Flexineering"—the science of applying flexible tubing to fit the particular needs of your plant—assures the right tubing on each installation.

When you require metal tubing that is tight as a pipe, but flexible . . . safe at high temperatures . . . and free from metal fatigue specify Penflex. Write for your copy of "Flexineering" today.

Pennsylvania Flexible Metallic Tubing Company, Inc.,
7240 Powers Lane, Phila. 42, Pa. *Branch Sales Offices:*
Boston • New York • Chicago • Houston • Cleveland
Los Angeles and Distributors in Principal Cities

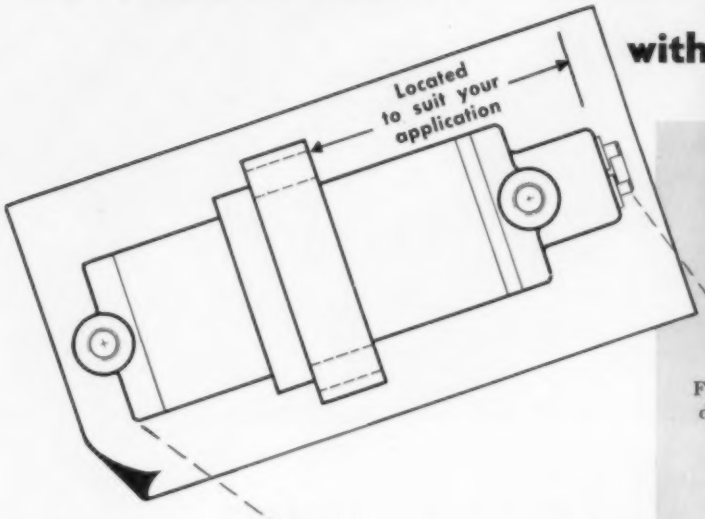
PENFLEX

HEART OF INDUSTRY'S LIFELINES

"We Saved 25% of the Cost of Base Castings"

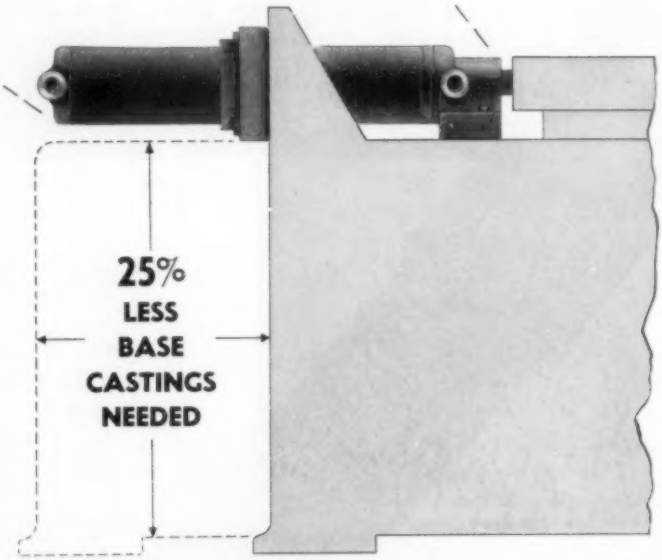
with

Pathon INTERMEDIATE FLANGE MOUNTING HYDRAULIC CYLINDERS



Application of the Pathon Intermediate Flange Mounting, as shown by the simplified drawing below, saved this machine company 25% of their base casting cost. Bonus advantages included reduced shipping weight, easier handling, and the universally recognized operating efficiency inherent in all Pathon Cylinders.

With Pathon Intermediate Flange Mounting Cylinders you choose whichever mounting position best suits your specific needs. Various heads of other mounting types may be combined with the intermediate flange to provide a large number of combination mountings. Thus special mounting brackets are eliminated. The cylinder is rotatable to any position for connecting pipe ports and mounting puds. Pathon Cylinders are available in the R. H. 2000 P.S.I. Series and the Q.H. 1000 P.S.I. Series.



HAVE YOU A HYDRAULIC CYLINDER MOUNTING PROBLEM?

The chances are that one of the standard eight Pathon Hydraulic Cylinder mounting types or their combinations will adequately fill it. However, on any unusual Cylinder problem, we will be glad to help you reach a solution. Don't hesitate to write us.

Pathon MANUFACTURING CO.

3823 PACIFIC AVE. — CINCINNATI 12, OHIO

"FOUR!"

Four? **That's right. Look closely, you'll notice this little golfer represents all four of the services available to designers from Sylvania's Parts Division: (1) Custom-molded plastics; (2) Plated, clad and alloy wire; (3) Metal stampings; (4) Electronic components.**

All of these parts were supplied in quantity to just one major manufacturer during the past year. On many of these items, Sylvania representatives were called in for consultation before parts designs were finalized. Suggestions from an experienced parts producer can often reduce costs, increase efficiency, and assure more uniform production in high volume items.

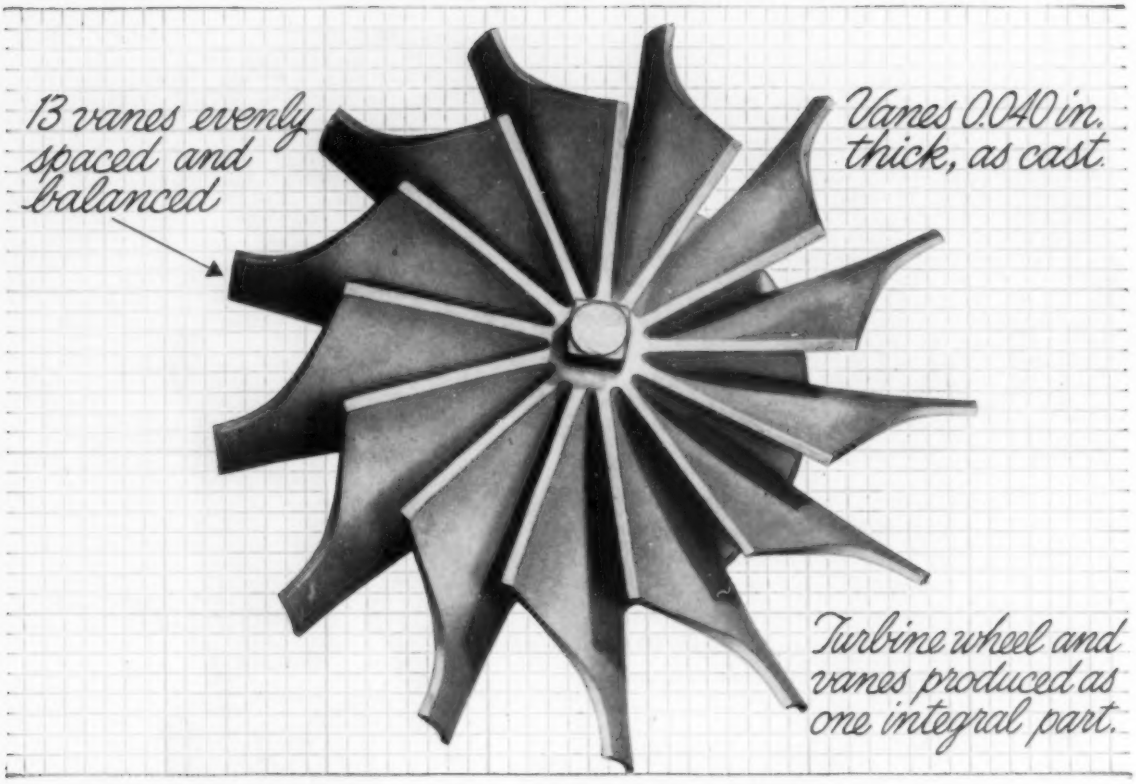
Manufacturers who insist on the highest degree of quality and efficiency can find Sylvania's 4-way service extremely helpful. For complete details write for the "Portfolio of 4-way Service to Designers." Address Dept. J33S.

SYLVANIA PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

SPECIAL WIRE · METAL STAMPINGS · MOLDED PLASTIC · ELECTRONIC COMPONENTS

4-way service from one source



Tough Design Problem Solved by Investment Casting . . . .

The precision-investment-casting process proved to be the most practical and economical way to produce an efficient turbine wheel for a diesel engine supercharger. The wheel rotates at 42,000 rev. per min. and is exposed to a 1450-deg. F. temperature. It had to be made of a hard-to-machine alloy capable of standing up under these severe service conditions. Yet, to operate efficiently, the vanes of the wheel had to be extremely thin and formed to an intricate shape.

The vanes and wheel were produced as one integral part by HAYNES' precision-investment casting process. Only two simple finishing operations were needed to put the wheel in service. The vanes are only 0.040 in. thick . . . too thin to produce by other methods without a prohibitive amount of machining on a hard, tough alloy.

The successful production of this turbine wheel points up one of the big advantages of HAYNES' precision-investment casting process . . . the planning freedom it offers to design engineers. For the full story on how this modern mass-production method can help you, contact one of the District Sales Offices listed below.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works: Kokomo, Indiana

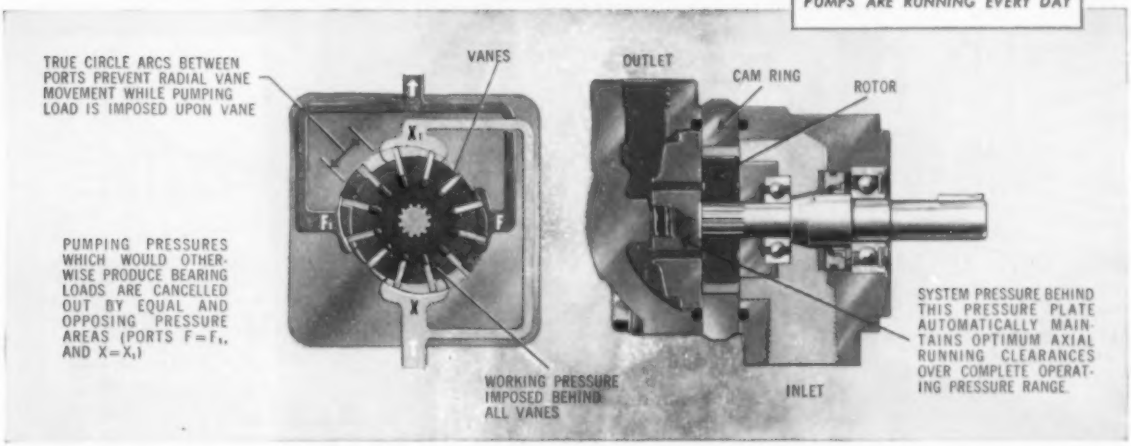
Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation

Question: Why are VICKERS® Balanced Vane Pumps the most widely used oil hydraulic power pumps on mobile equipment?

MILLIONS OF VICKERS VANE TYPE PUMPS ARE RUNNING EVERY DAY


TRUE CIRCLE ARCS BETWEEN PORTS PREVENT RADIAL VANE MOVEMENT WHILE PUMPING LOAD IS IMPOSED UPON VANE
VANES
OUTLET
CAM RING
ROTOR
PUMPING PRESSURES WHICH WOULD OTHERWISE PRODUCE BEARING LOADS ARE CANCELLED OUT BY EQUAL AND OPPOSING PRESSURE AREAS (PORTS F=F1, AND X=X1)
SYSTEM PRESSURE BEHIND THIS PRESSURE PLATE AUTOMATICALLY MAINTAINS OPTIMUM AXIAL RUNNING CLEARANCES OVER COMPLETE OPERATING PRESSURE RANGE.
WORKING PRESSURE IMPOSED BEHIND ALL VANES
INLET

Answer: Because of their SUPERIOR PERFORMANCE and MANY OTHER BENEFITS for the user.

For more than two decades, the Vickers balanced Vane Type has held the leading position among hydraulic power pumps . . . growing steadily in popularity. The various models (only a few shown below) are *the most widely used of all pumps in oil hydraulic service on mobile equipment.*

The many advantages listed hereafter merit the thoughtful attention of anyone concerned with the selection and use of oil hydraulic pumps for construction, automotive, agricultural and materials handling equipment.

COMPLETE HYDRAULIC BALANCE—Each inlet and outlet port is balanced by another equal in size and radially opposite . . . pressure-induced bearing loads are thus eliminated.

OPTIMUM RUNNING CLEARANCES—Both radial and axial clearances are automatically maintained over complete operating pressure range and throughout pump life.

FLOATING ROTOR DRIVE—Rotor is free to float, for correct centering and alignment, on a rigidly supported spline.

TRUE-CIRCLE CAM ARCS between ports prevent radial vane movement while pumping load is imposed upon vanes. Wear between vanes and rotor is thus practically eliminated.

EASIER COLD WEATHER STARTING—At normal engine starting speeds vanes are retracted . . . centrifugal force is insufficient to throw vanes outward into operating position . . . thus no pumping action takes place and pump drag on starting engine or motor is nonexistant. Only after engine starts is speed sufficient to extend vanes and begin pumping.

GREATER INSTALLATION ADAPTABILITY—Various types of mountings and four optional positions of pressure outlet connection. By unbolting and rotating pump head, the outlet can be placed parallel, opposite to or at a right angle in either direction to inlet. Shaft drive is in either direction depending only on internal assembly. Pump can be driven by belt, chain, gear or directly coupled.

HIGHER EFFICIENCY—Tests prove exceptionally high volumetric and overall efficiency . . . not only when pump is new but also after long service.

AUTOMATIC WEAR COMPENSATION—Vanes are held in contact with the cam ring by centrifugal force and hydraulic pressure. If wear occurs, vanes revolve in a slightly larger orbit without appreciable change in performance.

TEMPERATURE ADAPTABILITY—Correct running clearances are automatically maintained which compensate for wide variation in oil viscosity resulting from temperature variation.

MINIMUM MAINTENANCE—Hydraulic balance . . . optimum running clearances . . . floating rotor drive . . . automatic wear compensation eliminate the most important causes for maintenance and repair.

LONGER LIFE—The numerous features mentioned above that keep down maintenance also contribute to longer life.

COMPACT—These pumps occupy very little space in proportion to their capacities.

CONSTRUCTION SIMPLICITY is evident from the illustrations above. This simplicity is another reason for the superiority of Vickers Vane Pumps. For further information, ask for Bulletin M-5101.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
ADMINISTRATIVE and ENGINEERING CENTER
Department 1454 • Detroit 32, Michigan

Application Engineering Offices: ATLANTA • CHICAGO CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N.J.) • PHILADELPHIA AREA (Media) PITTSBURGH AREA (Mt. Lebanon) • PORTLAND, ORE. ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) SEATTLE • ST. LOUIS • TULSA • WASHINGTON WORCESTER
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

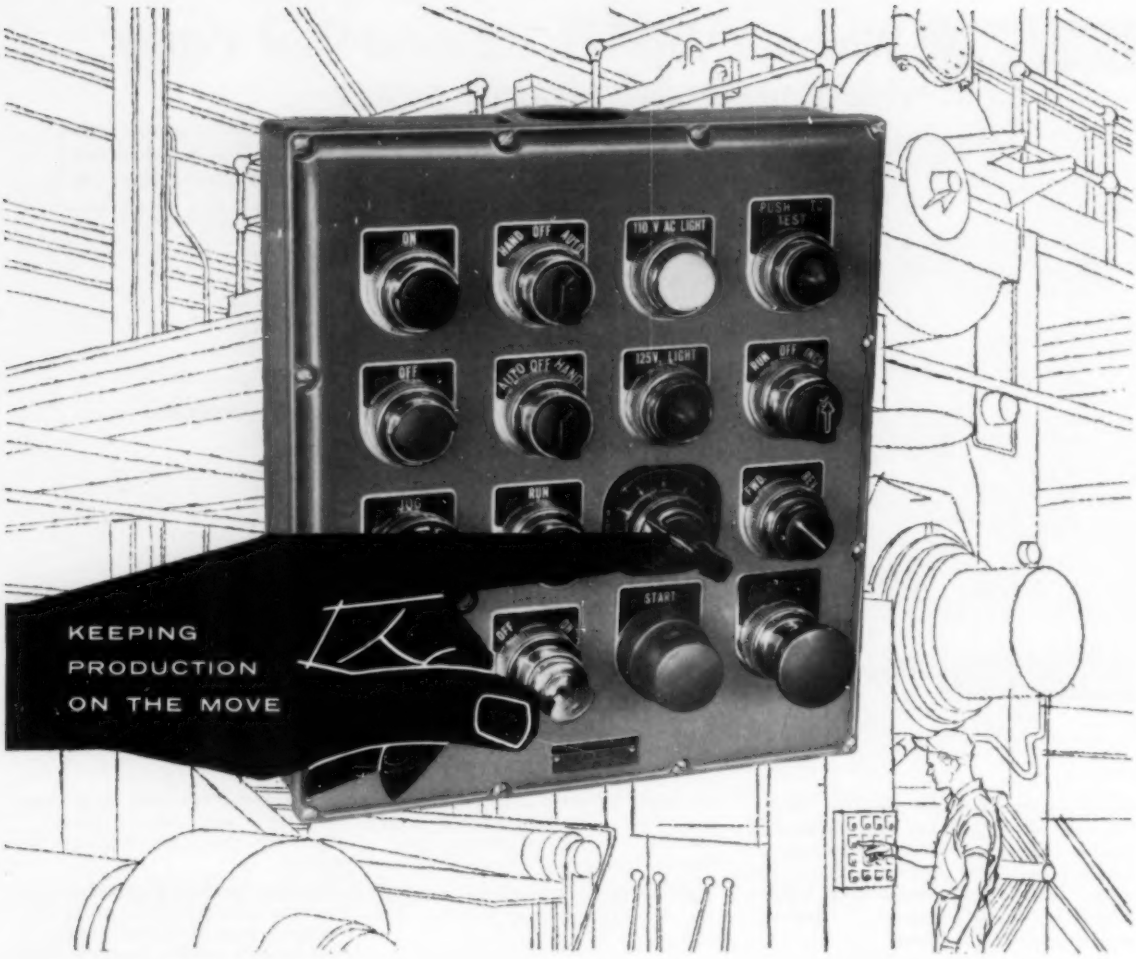
Single pump available in five basic case sizes having 15 normal delivery ratings. Operating pressures to 1500 psi (two largest units to 1000 psi).

Double pump for operating two independent hydraulic circuits from one power source. Available in 38 combinations. Operating pressures to 1500 psi (two largest units to 1000 psi).

"Package" type pump with integral volume control and relief valve, and oil reservoir; also available without oil reservoir. See Bulletin M-5107. (This pump only.)

ALL MODELS HAVE THE VICKERS ADVANTAGES MENTIONED ABOVE

7357



. . . with Westinghouse Oil-Tite control stations—1 to 16 units

Interchangeable parts — stations, contact blocks, operators and indicating lights — right off the shelf, quickly give you a "tailor-made" Westinghouse Oil-Tite* control station to meet the requirements of any heavy-duty industrial equipment application.

Enclosures — die-cast and Bonderized — include cork-neoprene gasketing and close machine fits as positive seals against exposure to oil, coolants, cutting compounds, water and other foreign matter.

*Trade-Mark

New Pushbutton Guide

For more facts on why it will pay you to standardize with Westinghouse control stations, get a free copy of the new *Pushbutton Guide*, booklet B-6749. See your nearby Westinghouse salesman or write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-30210

WATCH WESTINGHOUSE!

*WHERE **BIG** THINGS ARE HAPPENING FOR **YOU!***

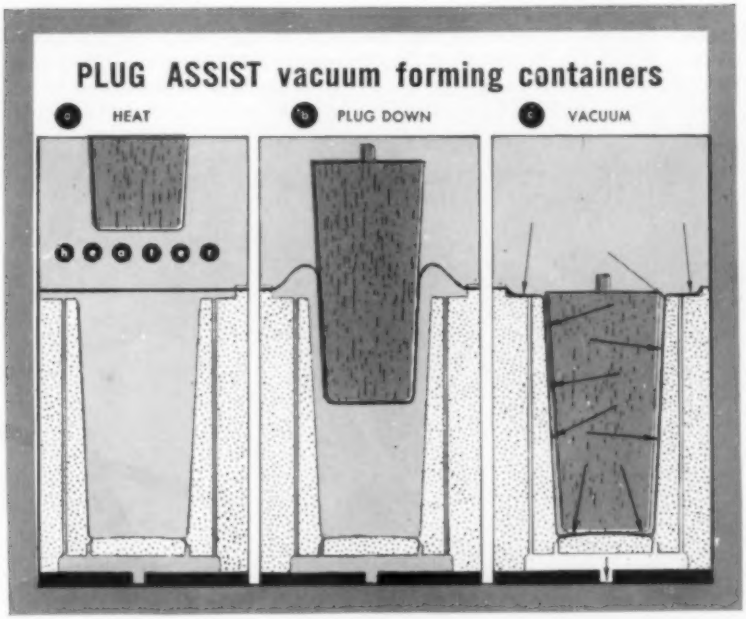
THERE'S A WESTINGHOUSE PUSHBUTTON TO MEET EVERY APPLICATION NEED!

DOW

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

"PLUG ASSIST" TECHNIQUE OFFERS NEW ADVANTAGES IN VACUUM FORMING



Increased flexibility in forming offers designers opportunities to make important new uses of plastic sheet

This improved fabrication method for polystyrene sheet products, developed by The Dow Chemical Company and called the plug assist technique, opens new horizons for the progressive designer. With more uniform wall thickness and more even distribution of material in deep-drawn, vacuum-formed parts, plastic sheet applications are increased many times. The added flexibility in design is made possible by a force plug which pre-forms the heated sheet in the cavity prior to drawing the vacuum.

Thorough plastiatrics research is continuously directed toward practical solutions such as demanded for the problem in forming sheet. Shearing or scoring is prevented by the slight air pressure produced between the sheet and the cavity until the plug stops traveling and the vacuum is drawn. The process has been thoroughly tested and appears to lend itself to high-speed automatic forming operations.

The plug assist method is only one of many contributions made by Dow Plastiatrics to every phase of formulation, design and molding for the plastics' industry.

SHEET AVAILABLE FROM MANY EXTRUDERS

In 1952, Dow introduced a method for extrusion of Styron® plastic high-impact sheet. Today, more than thirty extruders offer high-quality, uniform sheet products based on Styron plastic materials. Their names, and the names of qualified fabricators, will be gladly furnished by our nearest Dow Sales Office.

TECHNICAL LITERATURE OFFERED

Several technical bulletins are available at no cost for more detailed information on Styron high-impact plastic sheet for vacuum forming, pressure forming, stamping and embossing. Whatever your problem you may consult Dow with assurance of prompt, confidential help and advice. Write, on your letterhead, to THE DOW CHEMICAL COMPANY, Midland, Mich.—Plastics Sales Dpt. PL 435G-1.

AMERICA'S FIRST FAMILY OF POLYSTYRENES

GENERAL PURPOSE
- STYRON 666
- STYRON 665 (Extrusion)
- STYRON 688 (Easy Flow)
- STYRON 689 (Easy Flow)

HIGH IMPACT
- STYRON 475
- STYRON 429 (Extrusion)
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700

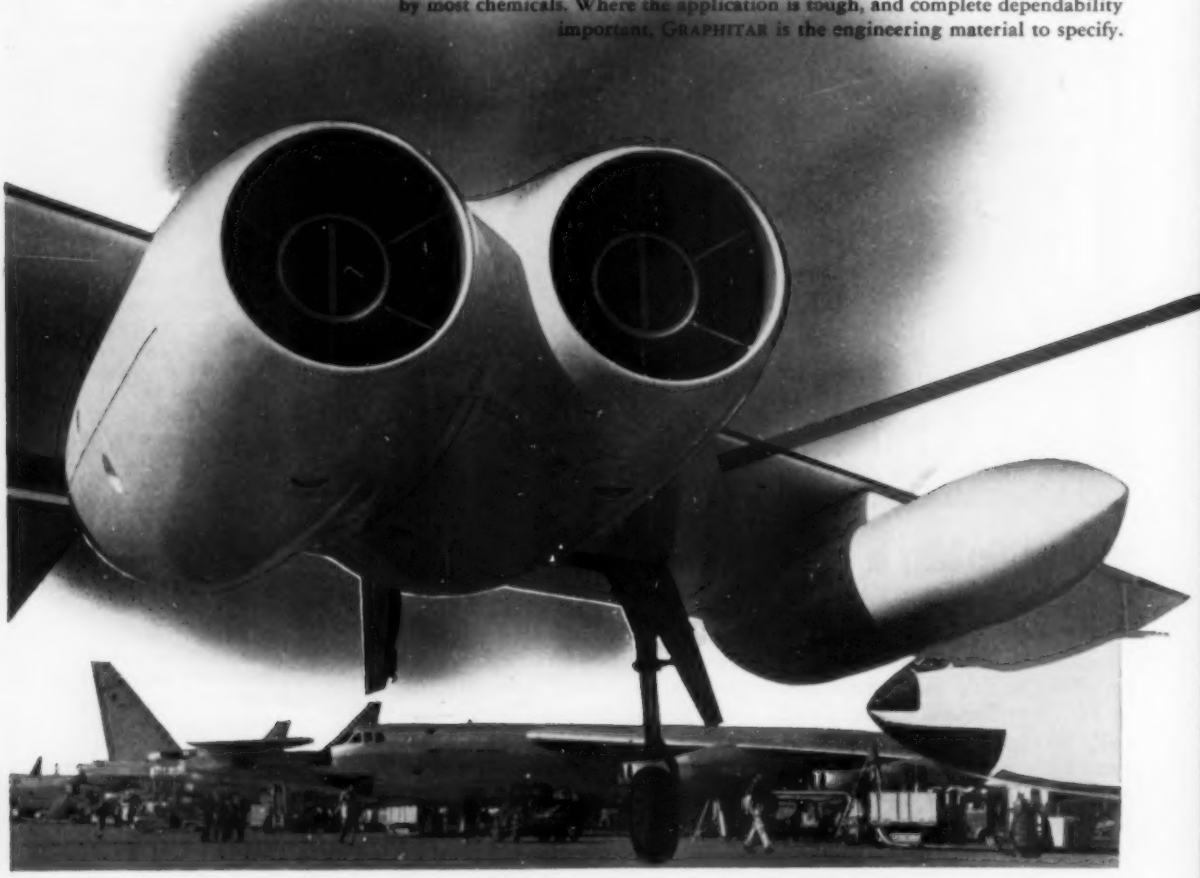
you can depend on DOW PLASTICS

DOW

GRAPHITAR® is the main shaft seal PRATT & WHITNEY J57 turbojet

(CARBON-GRAPHITE)

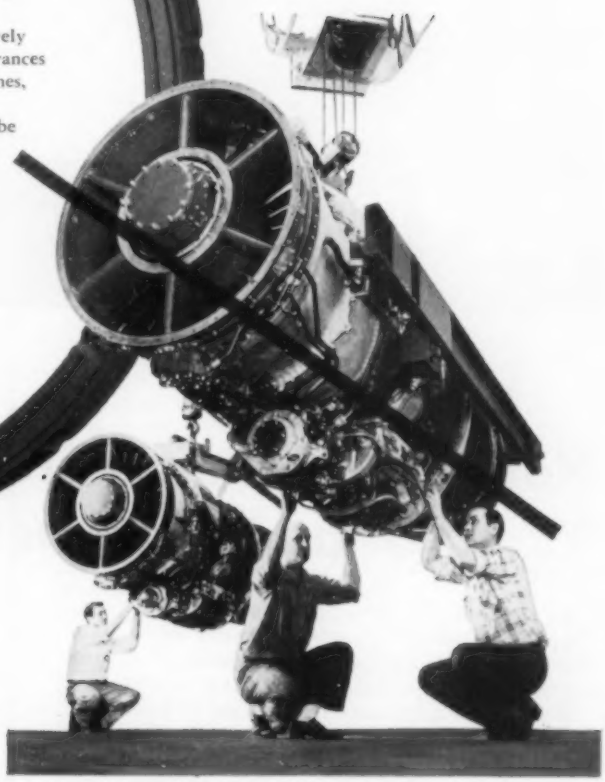
● Boeing's B-52 Intercontinental Bomber, the striking arm of our Strategic Air Command, is powered by eight twin-spool axial-flow turbojet engines manufactured by the Pratt & Whitney Aircraft Division of United Aircraft Corporation, East Hartford, Connecticut. These turbojets are in the 10,000 pound thrust class and in engines of this caliber, complete dependability is vital. One of the components of the J57 is a GRAPHITAR air/oil seal employed on the turbine main shaft which, naturally, is turning at high speeds. The GRAPHITAR seal also easily withstands the maximum operating pressures developed in the engine. The slots in the face of the seal shown on the opposite page (approximately ⅔ size) are for pressure balance and cooling. This Main Shaft Seal is just one of several GRAPHITAR seals used in the J57 engine. GRAPHITAR parts can resist such taxing physical conditions because they are strong, self-lubricating, and practically inert. GRAPHITAR has excellent wearing properties and cannot be corroded by most chemicals. Where the application is tough, and complete dependability important, GRAPHITAR is the engineering material to specify.



THE UNITED STATES

in the engine

● From the B-52 to the atomic submarine Nautilus, from automobile pumps to automatic toasters, GRAPHITAR is aiding the performance of literally hundreds of highly diverse products. This versatile engineering material is compacted under extreme pressure and fused at heats near 4500°F. It can be formed in relatively complicated shapes and ground to tolerances as close as .0005" for seals, bearings, vanes, piston liners, and many other parts. GRAPHITAR is self-lubricating . . . can be used where only steam or water are present. It is lightweight, strong, durable, chemically inert, and is virtually unaffected by extremes of heat, pressure, or temperatures.



write for your copy of the new **GRAPHITAR** *Engineering Bulletin No. 20*

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

Alnico permanent magnets power the new Eriez Ferrotrap, visible above at left of the paper. Trap body and cover plate are Type 316 stainless chromium-nickel steel, non-magnetic and easy to clean.

How Alnico guards products and machines ...traps tramp metal continuously

This operator holds a collection of nails, paper clips and other ferrous contaminants. All were removed by the Eriez Ferrotrap from liquid caramel being pumped through a candy plant pipeline.

Keeping hot, viscous caramel free of tramp iron is an obviously difficult task. But a new Eriez unit, aptly named the Ferrotrap, does this sort of job with multiple rods or "fingers" containing Alnico permanent magnets.

No need for electromagnets, current and accessories, because at temperatures up to 850°F the powerful, life-time magnetic strength of a high nickel alloy . . . Alnico . . . assures positive trapping of iron particles. Even nuts, bolts, and the like.

Units that protect not only product purity, but also filters, mixers, pumps and other costly equipment are made practical by the powerful magnetic properties of Alnico, an aluminum-nickel-cobalt-iron alloy.

Nickel . . . an essential element in Alnico . . . improves hundreds of other alloys utilized in industry. So if you have a problem involving metals, consult us on the use of nickel or nickel alloys. But if you wish further information about the Ferrotrap, write Eriez Manufacturing Company, Erie 6, Pennsylvania.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.

NEW SWITCH NEWS

FOR CIRCUIT DESIGNERS

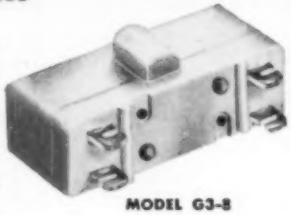
New subminiature sealed switch is environment-free; mounts interchangeably with MS25085

MODEL EF-3

Single Pole, Double Throw
Move. Differential, .004 Max.
Overtravel, .003 Min.
Oper. Force, 5 to 17 oz.
Release Force, 60 gram
Elec. Life Ratings:
150,000 ops. @ 125/250 V. A.C., 2.5 AMP.
100,000 ops. @ 125/250 V. A.C., 5.0 AMP.
50,000 ops. @ 30 V. D.C., (2.5 AMP., IND.; 4.0 AMP., RES.)
Amb. Temp., −65° to +180° F.

Sealed in a corrosion-resistant, treated aluminum enclosure, this tiny switch is environment-free; highly vibration and shock resistant. It carries 5 amps. at 125/250 V.A.C. with an electrical life rating of 100,000 operations. Low operating force and small movement differential make it ideal for bi-metal temperature, diaphragm operated and other "feather-touch" devices, while small size permits mounting singly or ganged in restricted space. Rugged and dependable, it has positive snap action.

Tiny, new 40 amp. basic switch has high capacity, longer life and constant stability of tolerances



MODEL G3-8

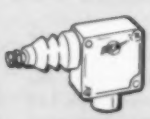
Measuring only 1¾" x 43/64" x 43/64", the new Electro-Snap G3-8 Basic Switch handles current ratings up to 40 amps. A new method of combining Electro-Snap's double-break action with a heavy-duty switching element assures electrical and mechanical life of 100,000 cycles at large capacities; also provides constant stability of tolerances and accurate repeatability. New plastic compound case gives the switch an ambient temperature rating of −65° to +300° F. with extreme shock resistance. Small size makes it ideal for motor controls and compact automation set-ups. A wide range of actuators is available.

OPERATING CHARACTERISTICS

Single Pole, Double Throw
40 AMPS @ 125/250 V. A.C.
@ 30 V. D.C. Res.
Oper. Force, 30 ozs.
Overtravel, .025" Min.
Move. Differ., .055 ± .010

PRECISION SWITCHES

BASIC SWITCHES

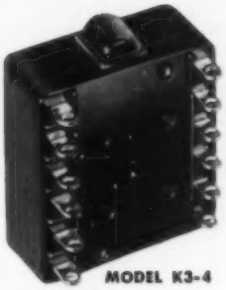


DIECAST ENCLOSED SWITCHES

HERMETICALLY SEALED LIMIT SWITCHES

CONFORM TO MIL & AM SPECIFICATIONS

New simultaneous triple-pole switch interrupts 3-phase ac. circuits; 6-circuit control in a small package



MODEL K3-4

Triple-Pole, Double Throw
15 AMP., 125/250 V. A.C.
.30 V., D.C. Res.
10 AMP., 30 V., D.C., Ind.
Overtravel, .015 Min.
Move. Diff., .028 ± .007
Mech. Life, 1,000,000 ops.
Elec. Life, 500,000 ops.

This completely new Electro-Snap triple-pole switch simultaneously reverses current flow through three windings of a 3-phase motor up to 1 H.P. and interrupts other types of multi-switching installations. Instantaneous "make" and "break" snap-action of the three poles is independent of the speed of actuation—even extremely slow moving cams can be used.

The K3-4 Series offers designers a wide variety of 3-phase circuit hookups for servo-controls, to limit movement of machine members and as a start-and-stop switch which formerly were possible only with complicated relays or a number of separate switches. A large selection of standard actuators is available.

New small basic switch is low cost; directly interchangeable with AN3234 Specs

F2 SERIES

The new Electro-Snap F2 Series snap action switches are extra-compact with extremely high electrical capacity for their size. Mechanical and electrical life at 1/32" overtravel is 150,000 operations, minimum, with accurate repeatability and constant stability of tolerances. Self-aligning springs provide contact wiping action rare in a switch of this size.

Durable case of special plastic gives the switch an ambient temperature rating of −100° to +275° F. or +375° F. Available, *at low cost*, in three basic models with a wide selection of actuators.

SERIES F2 BASIC SWITCH: F2-3: Single Pole, Double Throw
F2-2: Single Pole, Normally Open; F2-1: Single Pole, Normally Closed

OPERATING CHARACTERISTICS

Electrical Rating: 10 AMP. 125/250 V. A.C. 60 cycles
30 V. D.C. inductive and resistive (6 AMP, 30 V. D.C. for Airborne Application)
Operating Force, 7 to 12 oz.
Reset Force, 4 oz. Min.
Pretravel, 3/64 Max.
Movement Differential, .011 ± .005
Overtravel, 1/32 Min.

SEND COUPON FOR MORE DATA

ELECTRO-SNAP SWITCH & MFG. COMPANY
4246 W. Lake St., Chicago 24, Ill.

Please send data sheets on switches checked:

- ☐ EF-3 — subminiature sealed
- ☐ G3 — 40 Amp. basic
- ☐ K3 — Triple-pole
- ☐ F2 — Extra-small basic

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

Because these solenoid covers are essential to valve operation, they are chained to the valves. Also, they fasten with 4 "captive" screws that cannot be mislaid. A manual operating button makes it possible to operate the valve without removing its cover.

Now! solenoid-controlled air valves that defy improper maintenance ...they won't operate with their covers off!

When a solenoid valve operates without its cover, trouble is not far off. Dirt, oil, cutting fluid, chips are sure sooner or later to jam the solenoid, and the valve will fail to shift.

That can't happen with these new Hannifin valves!

The solenoids are held in place by their covers and won't operate the valves unless the dust-tight, splashproof covers are firmly tightened.

These new valves, which conform to the latest J.I.C. recommendations, are part of the complete "P-M" Pilot-Master line. New heads with these new solenoid covers are offered on 2-way, 3-way and 4-way Pilot-Master Valves (air-operated). The smaller, direct-operated 3-way and 4-way valves in the "P-M" line have been redesigned to use the same new covers. This added feature is just another reason why it pays to standardize on Hannifin air control valves.

AIR CONTROL

HANNIFIN

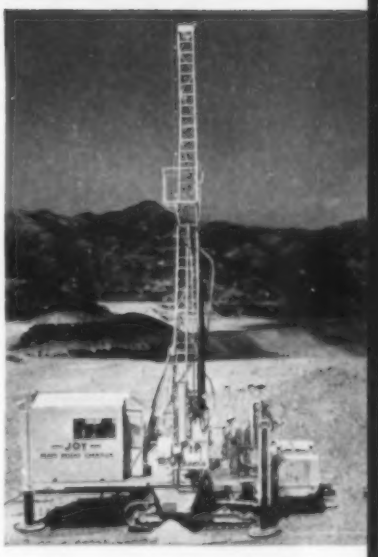
VALVES

Complete information on all Hannifin Air Control Valves is in this catalog. It belongs in your files. Write for your copy. Hannifin Corporation, 525 S. Wolf Road, Des Plaines, Illinois.

▲ **TWO-AND-A-HALF-INCH SEALTITE** containing motor lead cable is attached to rigid conduit on Super Heavy Weight Champion Drill. Flexibility of Sealtite means fast, simple installation.

◀ **ONE-INCH SEALTITE** is installed to junction box. This particular box is necessary because tower must be removed for shipping. Sealtite withstands weathering, dust and vibration.

HEAVY WEIGHT CHAMPION Drill takes 40 ▶ feet of Sealtite in three sizes. Big brother, Super Heavy Weight, uses about 200 feet of flexible, liquid-tight conduit.



Flexible, liquid-tight conduit speeds up wiring on blast hole drills

"Sealtite" cuts installation time 20%—drill manufacturer reports

This large drill is not pampered. It is used in the field under every conceivable climatic and atmospheric condition. Thus, every component, including the electrical conduit, must be rugged to stand the weather, the abrasive dust and severe vibration.

Formerly, the manufacturer used a rigid type of conduit. But it was difficult to install around bends and in tight spaces. In 1953, they switched to Sealtite flexible, liquid-tight conduit. This flexible conduit has meant a 20% saving in labor time, improved the appearance of the wiring job—and all the time has delivered 100% in the field.

Manufacturers find Sealtite easier to stock . . . takes up less storage space.

WHERE TO GET SEALTITE

Electrical wholesalers stock Types U. A. and E. F.† Sealtite* flexible, liquid-tight conduit in easy-to-handle coils. Be certain you ask for, and get, the quality conduit marked "Sealtite" on the cover. Buy it in long lengths and cut it on the job without waste. Special liquid-tight connectors by Appleton, Thomas & Betts, Gedney or Pyle-National are available. Free Booklet S-537 gives full information on Sealtite. Write: The American Brass Company, American Metal Hose Division, Waterbury 20, Conn.

*Trade Mark †Pat. Applied for 56192

Insist on the original

SEALTITE

flexible, liquid-tight conduit

an **ANACONDA**® product

Where Dependability is Vital...

HEIM *Unibal* ROD ENDS

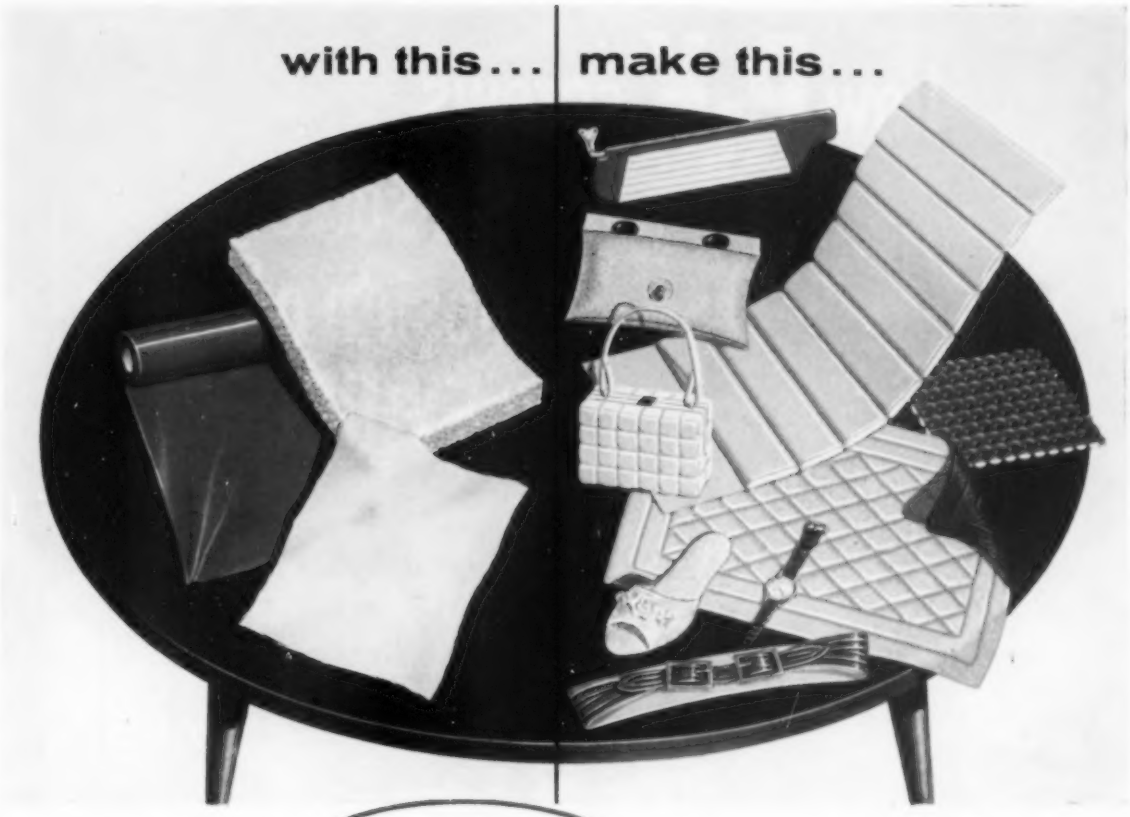
at each end of the linkage connecting the bellcrank and the piston wrist pin, operate the all-important air pump in this Technicon-Huxley Chest-Abdomen Respirator. In this application, the Heim Rod Ends eliminate all bind in the reciprocating piston and all noise and play, even after long and constant use.

This respirator, made by Conitech, Chauncey, N. Y., is completely portable and is an improvement over the iron lung, as it leaves the upper and lower extremities of the patient free, permitting sitting-up, exercising of the limbs, and nursing care. Constructed for long-time continuous operation, the power unit is a positive displacement piston mechanism, operated by the Heim Rod Ends, which delivers a volume of about 1100 cu. in. per stroke.

Heim has an informative, illustrated catalog of Unibal Bearings and Rod Ends as well as all other Heim bearings. Send for your copy and use Heim's engineering service for any linkage problem.

THE HEIM COMPANY
FAIRFIELD, CONN.

The single ball principle of the Heim Unibal corrects misalignment, reduces friction, and offers smoother operation and greater freedom of movement in any application.



now truly HEAT SEALABLE foam... VINYL foam

and suddenly 1000 great ideas are possible!

Development of *heat-sealable* Vinyl-foam, makes new quality, new ideas possible in hundreds of products that require cushioning or softness, fashionably molded contours, eccentric or specially-designed shapes, quick-quilted and embossed surfaces.

In all these ideas, quality is maintained. Electronic heat-sealing affects none of Vinylfoam's many desirable properties.

Exon 654, vinyl plastisol resin helps make Vinylfoam unusually resistant to abrasion, corrosion, flame, aging, moisture, tearing and chemical action. Prevents shrinking, oxidizing, hardening or drying out, all with maximum dimensional stability.

Vinylfoam, produced by the Elastomer Process, can be molded in either cored or uncored form, with or without surface contours. It can be embossed, die cut, split or skived. You can bond Vinylfoam directly onto textiles, most synthetics, and on vinyl sheeting or film in continuous lengths.

Vinylfoam is so versatile that products in almost every industry can acquire new comfort, safety and durability. And with vinyl's economy, they will cost less, sell better.

because it's made of

Firestone

VERSATILE VINYL RESINS

engineered answers to industry's needs

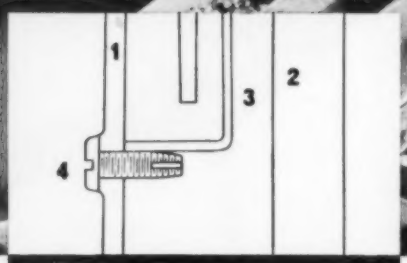
Firestone Plastics Company supplies only the plastisol resin . . . does not make the finished foam.

For complete information or technical service on EXON resins, industry's most complete line of versatile vinyls, call or write:

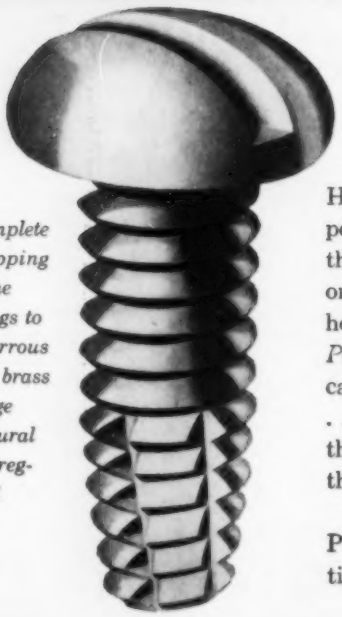
CHEMICAL SALES DIVISION

FIRESTONE PLASTICS CO., DEPT. 66N, POTTSTOWN, PA. • A DIVISION OF THE FIRESTONE TIRE & RUBBER CO.

how P-K® screws helped solve a design problem for EVINRUDE



1. DRIVE HOUSING
2. DRIVE SHAFT
3. EXHAUST BAFFLE
4. P-K TYPE F SCREW



Type F (one of a complete line of P-K Self-tapping Screws) used for the making of fastenings to ferrous and non-ferrous castings, bronze or brass forgings, heavy gage sheet metals, structural steel, plastics, impregnated plywood and other materials.

How do you keep a baffle from dropping down out of position? Designers of Evinrude outboard motors found the answer. No need for an expensive tapping operation or for a complicated stamping. Simply provide a cored hole in the casting, insert the stamping and then drive a *Parker-Kalon* Type F Screw through the hole in the die-cast housing. The screw acts as a retainer for the baffle . . . and because it is a *Parker-Kalon* Self-tapping Screw, there is no chance of its loosening during the operation of the motor. Yet it can be removed, if necessary.

This application is one example of the versatility of P-K Screws which designers can employ for various functions supplementary to fastening.

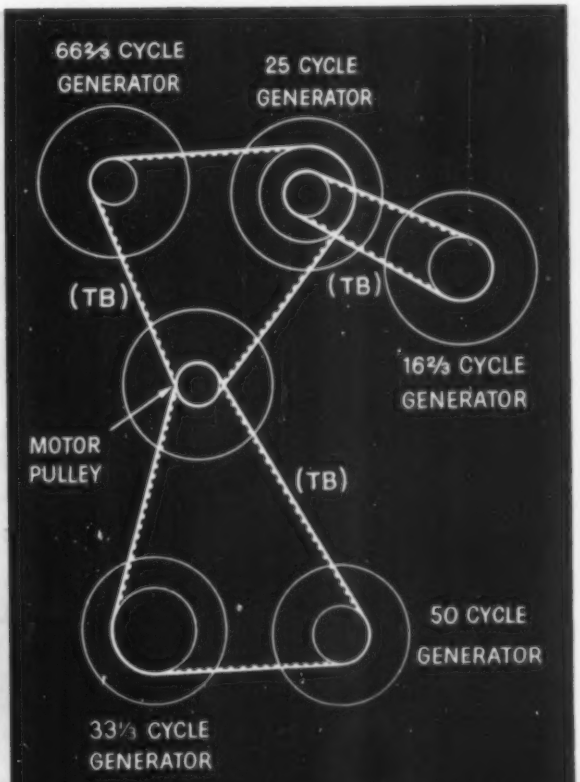
PARKER-KALON® fasteners

PARKER-KALON DIVISION, General American Transportation Corporation
Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws

Sold Everywhere Through Leading Industrial Distributors
Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois—Los Angeles, California

US RUBBER **PowerGrip "TIMING" BELTS**

Making one motor do the job of five



Above is a schematic drawing of a 5-frequency telephone ringing unit on a party-line system. Previously, five motors were needed to generate the different ringing frequencies. But with the installation of just *three* U.S. PowerGrip "Timing" Belts (TB) *only one motor is needed* now. That's because U.S. PowerGrip provides a positive, non-slip grip that preserves the exact speed ratios and the synchronization needed to maintain critical frequencies. And there is absolutely no measurable power loss.

This is one more example of the U.S. PowerGrip "Timing"® Belt's ability to simplify and improve a power transmission unit . . . one of the reasons why the invention of U.S. PowerGrip "Timing" Belt was recently awarded the Franklin Institute's Edward Longstreth Medal for "Invention of High Order."

Whether it's for the design of hand tools, lathes, drill presses, saws, electric typewriters—from fleapower to horsepower—U.S. PowerGrip offers all these advantages:

- *no slippage, no take-up—allows short centers, high ratios.*
- *absence of metal-to-metal contact—eliminates need for lubrication and housing devices.*
- *handles speeds up to 16,000 F.P.M. or so slow as to be imperceptible to the eye.*
- *close to 100% efficiency.*
- *imbedded with steel cables for high tensile strength*
- *constant angular velocity.*

These belts—plus expert engineering service—are obtainable at "U.S." power transmission distributors, at any of the 28 "U.S." District Offices, or by writing us at Rockefeller Center, New York 20, N. Y.

Watch NCAA football, Saturday afternoons, NBC-TV

US RUBBER **Mechanical Goods Division**

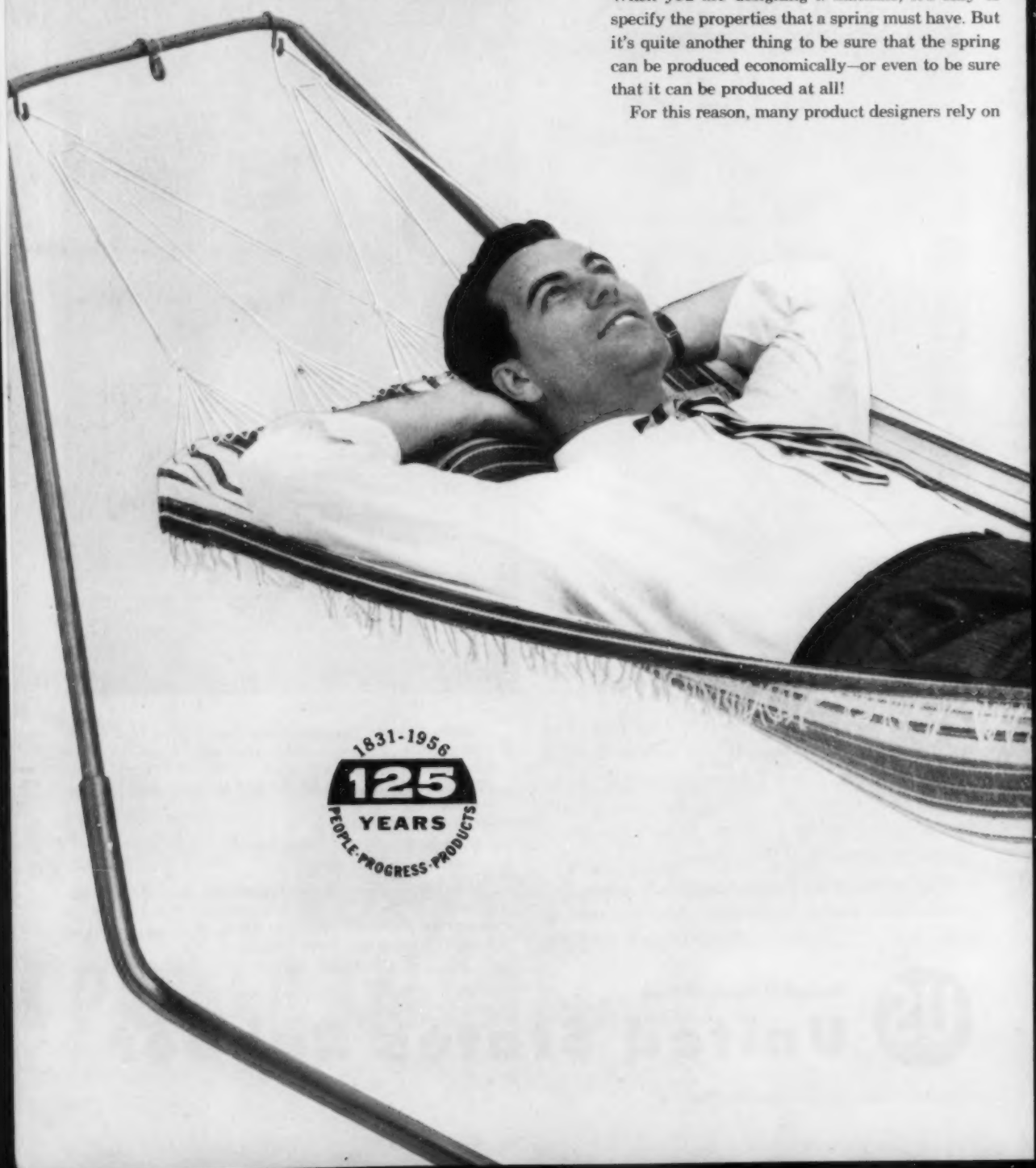
United States Rubber

TAKE IT EASY!...

let American

When you are designing a machine, it's easy to specify the properties that a spring must have. But it's quite another thing to be sure that the spring can be produced economically—or even to be sure that it can be produced at all!

For this reason, many product designers rely on



1831-1956
125
YEARS
PEOPLE · PROGRESS · PRODUCTS

when you have a spring problem Steel & Wire worry *for* you

specialists to help with spring design; and, believe it or not, even in these times of inflation, the specialists are free.

We refer, of course, to the spring engineers at American Steel & Wire. When you come down to the last phase of a new design, call in your American Steel & Wire representative. Perhaps a small specification change here, and a little design change there, will give you a *better* spring for the job, capable of mass production in high-speed machines with the obvious advantage of lower costs.

Just call your AS&W salesman.

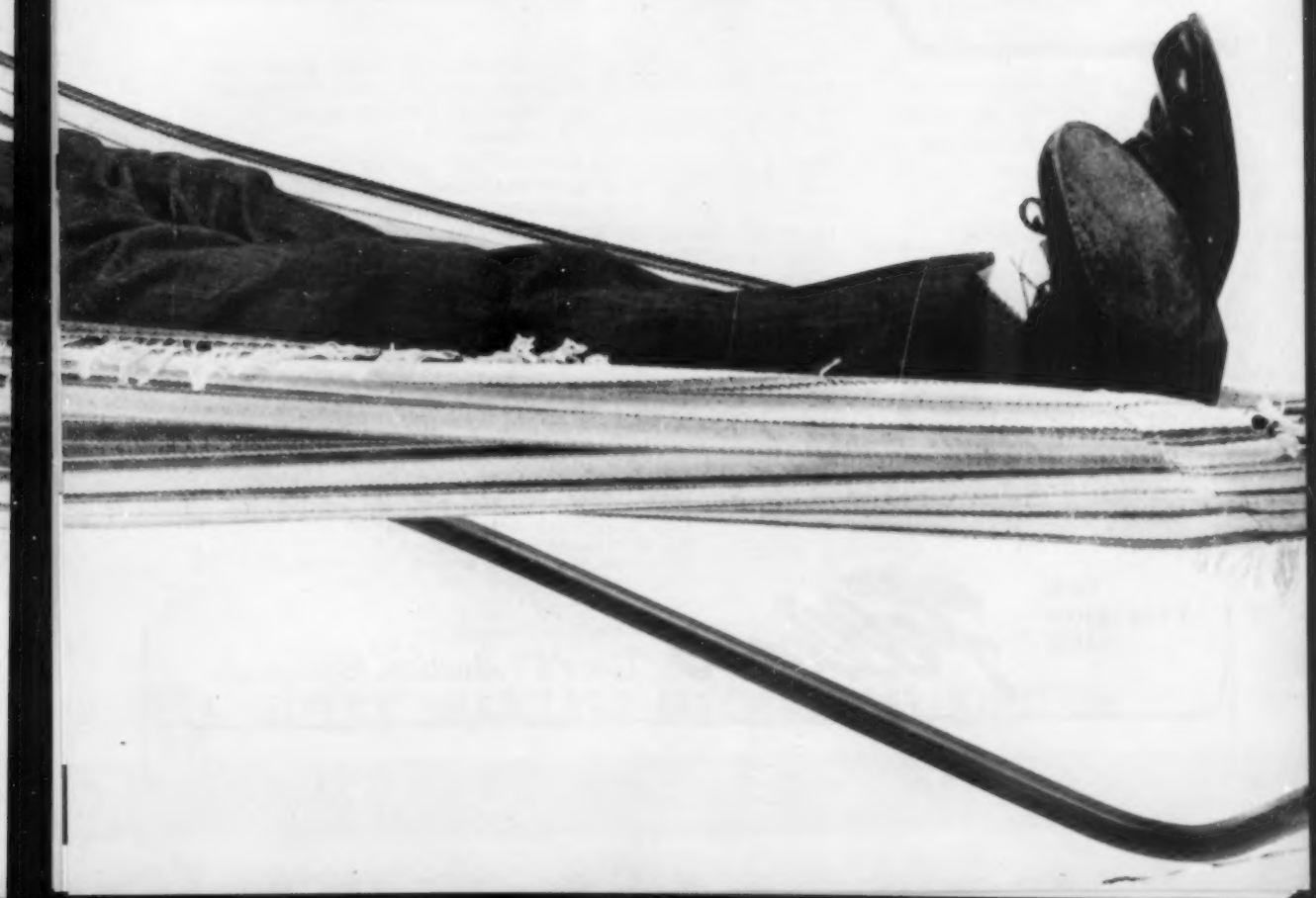
AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO

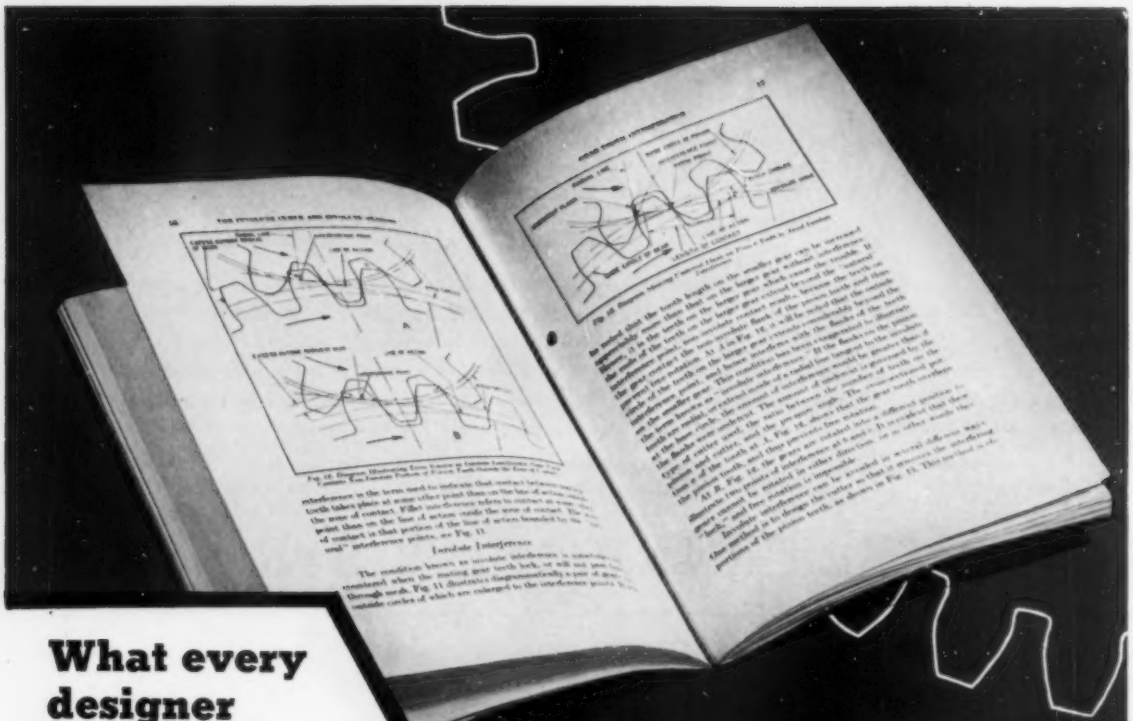
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS

UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS AMERICAN *QUALITY* SPRINGS

UNITED STATES STEEL





What every designer should know about involute gears

The properties of the involute curve as a gear-tooth profile offer many possibilities in the design of gears. To take full advantage of them, you must know the three basic elements of gear design and the fundamental laws of the involute curve.

These are stated in "The Involute Curve and Involute Gearing," a complete treatise on Involute Gear Design. The contents of this booklet also include such useful subjects as the function of gearing, the application of the involute to gear teeth, the Gear Shaper Cutter, generating involute gears on the Fellows Gear Shaper, checking profiles on Fellows Involute Measuring Instruments and definitions of gear tooth elements. A copy is yours for the asking. Just write any Fellows Office.

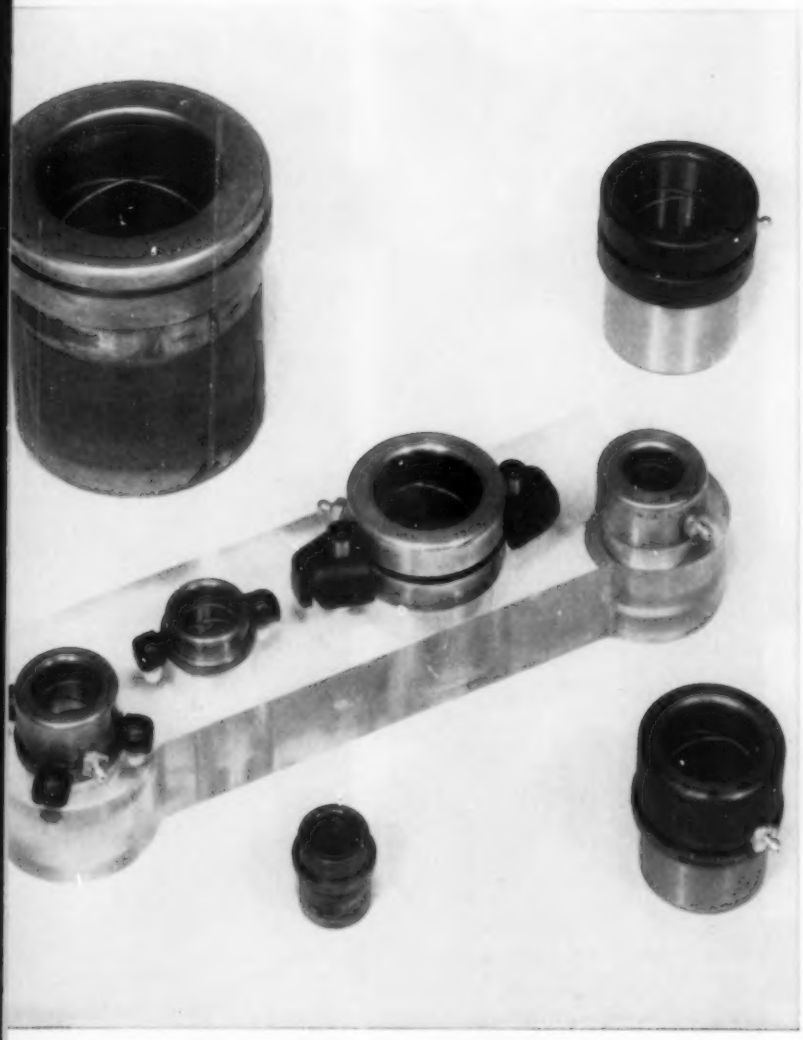
You should also know that in addition to providing speed and accuracy in generating involute gears, the Fellows Gear Shaper provides an economical means for generating many non-involute shapes such as sprockets, cams and other irregular contours.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices: 319 Fisher Building, Detroit 2
5835 West North Avenue, Chicago 39
150 W Pleasant Ave., Maywood, N. J.
6214 West Manchester Avenue, Los Angles 45

THE PRECISION LINE **Fellows** *Gear Production Equipment*

How a better precision-fit Guide Pin Bushing* is made in less time with

SHELBY SEAMLESS MECHANICAL TUBING



Here is another manufacturer that is turning out a better product in less time by using Shelby Seamless Steel Tubing.

The product, a wring-fit bushing, makes possible a truly precision die set, which permits closer working tolerances and extends the life of the dies to a degree never before thought possible. The bushing itself is harder, stronger, more uniform, longer lasting and better fitting.

When Shelby Seamless Tubing is used, no boring is necessary—the hole is already there. It offers more, however, than just a pre-bored hole. It combines to an exceptional degree the qualities of strength, uniformity, and dimensional accuracy. These advantages, coupled with the workability and excellent machining properties of Shelby Seamless, make it the ideal material for critical mechanical applications like this.

Available in a wide range of diameters, wall thicknesses, various shapes and steel analyses, Shelby Seamless Mechanical Tubing is produced to exacting standards by the world's largest manufacturer of tubular steel products. Get in touch with our engineers if you would like help in applying Shelby Seamless to your specifications.

*Manufacturer's name on request.

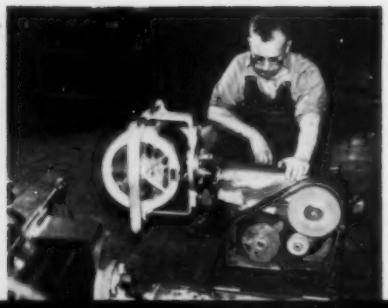
NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
(Tubing Specialties)
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS **SHELBY SEAMLESS MECHANICAL TUBING**

UNITED STATES STEEL

20 Case Histories of G-E Motor Benefits

AMERICAN COOLAIR CORP.
"customers like 'no-reoiling' feature"†



RED DEVIL TOOLS
"stands up under severe vibration"

CAMPBELL-HAUSFELD CO.
"makes product easier to sell"

BUCKEYE INCUBATOR CO.
"customers say 'they're dependable'"

TRUFLOW FAN COMPANY
"never had a motor failure"

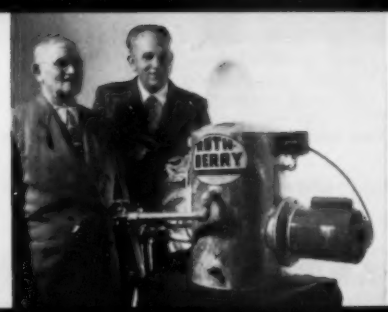
UTILITY APPLIANCE CORP.
"virtually trouble-free service"

BERKELEY PUMP CO.
"lighter weight, modern appearance"

GENERAL WIRE SPRING CO.
"more than adequate power reserve"

W. M. CISSELL MFG. CO.
"easier to handle and install"

PENBERTHY INJECTOR CO.
"allows maximum design flexibility"



A. P. RUTH & CO., INC.
"speeds assembly, saves on shipping"

PERMUTIT COMPANY
"saved $8 per unit"

—HOW MANY APPLY TO YOU?

METALMASTER CORP.
"wide customer acceptance"

MASTER-BILT REFRIG. MFG. CO.
"standardized 100% with G. E."

AMERICAN DUPLEX CO.
"unexcelled durability"

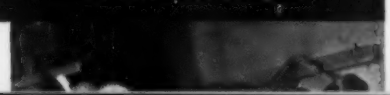
GOLD MEDAL PRODUCTS CO.
"saved 18% in shipping costs"

C. M. SORENSEN CO., INC.
"reduced weight 15%"

ALVEY CONVEYOR MFG. CO.
"all-angle mounting sold us"

MOUNTAIN STATES EQUIP.
"cut weight nearly 10 lbs."

TAIT MANUFACTURING CO.
"neater, more compact"



"YEARS-AHEAD" MOTOR

THESE G-E FHP MOTOR FEATURES ENABLE YOU TO IMPROVE YOUR PRODUCT, YET CUT COSTS

The twenty case histories at left are typical of the profit-building experiences of thousands of manufacturers using General Electric motors. The reason is simple—only G.E. gives you *all* of these outstanding features, combined into a complete line of smaller, lighter motors.

1. SMALLER, LIGHTER DESIGN—The trend to modern appearance and portability is reflected in this General Electric motor. It's 40% smaller, 50% lighter than old-style designs.

2. MYLAR* POLYESTER FILM INSULATION—It has over 35 times more moisture resistance, 8 times more dielectric strength than ordinary paper insulation.

3. ALL-ANGLE OPERATION—General Electric's all-angle lubrication system gives you positive lubrication regardless of mounting position. As a result, you can often avoid the higher cost of "special" motors.

4. EASY CONNECTION—A speed nut welded inside the motor shell permits fast, easy connection of conduit fitting.

5. MOUNTING VERSATILITY—This G-E motor, whether resilient or solid-base, can be rotated inside its cradle to obtain complete mounting versatility. The cradle may also be removed entirely to meet your design needs.

6. DOUBLE LUBRICATION LIFE—The General Electric combination of a larger oil capacity (50% more than old style designs), and an efficient oil retention system means minimum motor maintenance for you.

Thousands of manufacturers have already used millions of these "Years-ahead" G-E motors. Why not evalute your own motor savings in terms of these G-E motor benefits?

For more information, contact your nearby G-E Apparatus Sales Office, or write Section 702-29, General Electric Co., Schenectady, New York.

** DuPont registered trademark.*
†Feature of G-E summer cooling fan motors.

GENERAL ELECTRIC

How Mayari R lengthened the life of these mixer drums

Mixing mortar or terrazzo in a machine like this one puts the steel mixing drum through quite an ordeal. In earlier models the abrasive action of the batch against the drum walls caused excessive wearing of ordinary carbon-steel drums.

For longer drum life the Muller Machinery Co., Inc., of Metuchen, N. J., decided to utilize the superior abrasion-resistance of Mayari R steel. Now, using Mayari R sheet as heavy as 4-gage, they rotary-shear it, multiple-punch it, roll-form it, and weld it into a drum that outlasts the previous drums of carbon steel. And Mayari R has proved to be as readily workable and weldable as the steel they had used before.

Abrasion-resistance is by no means the only advantage to be gained in using Mayari R high-strength, low-alloy steel. Its high yield point permits designs of greater strength or lighter weight. It has 5 to 6 times more resistance to atmospheric corrosion than plain carbon steel, and holds paint up to 80 pct longer.

Catalog 353 covers the Mayari R subject in complete detail. A copy may be obtained promptly by writing to the nearest Bethlehem office.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

Mayari R...High-Strength, Corrosion-Resisting Steel

BETHLEHEM STEEL

Design data on adhesives

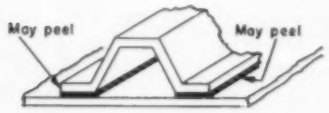
Armstrong
ADHESIVES • COATINGS • SEALERS

NUMBER FIVE

How to minimize peel by changing stiffness

When stiffening members are attached to thin sheets, the sheets may deflect in service and set up peel stresses on the adhesive. Such peel stresses exerted on rigid adhesives can cause failure. Some structural adhesives, however, resist peel more than others. Proper design, too, can help.

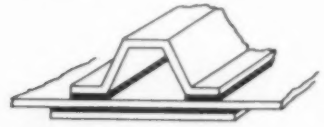
For example, if the flanges on the stiffening section can deflect with the sheet, the peel problem will be minimized. Thus, reducing the stiffness of the flange on the stiffening section should result in improvement . . . as will increasing the stiffness of the base sheet itself. How stiffness may be changed to minimize peel is shown below.



Basic assembly

Reduce flange stiffness with taper

Reduce flange stiffness with grooves



Increase base sheet stiffness with extra member

For more information

Write for a copy of "Armstrong Adhesives, Coatings, and Sealers." Armstrong Cork Company, 8010 Irvin St., Lancaster, Penna.

BONDING METHODS:
Wet assembly and contact bonding

Basically, assembly with adhesives involves placing cleaned and coated parts together, with the surfaces to be bonded held in intimate contact until the adhesive sets. There are various techniques for doing this, depending on the materials, their shapes, and the properties of the adhesive.

Wet Assembly

This technique involves bringing the bonding surfaces together while the adhesive is liquid and holding them in this position with pressure until the adhesive sets or develops its bonding strength.

BONDING VINYL TO METAL. Here, adhesive is being sprayed on the vinyl covering and end posts of a folding door. This kind of application, where clamping is impracticable, requires an adhesive with high immediate strength.

With porous materials such as wood or paper, adhesives used can set chemically, or through the loss of volatile material, or merely through cooling as with hot melts. With nonporous materials, such as metal and plastics, loss of volatile material is practically impossible except at edges. With these materials, the adhesives used must be of the kind that set through chemical action, through cooling, or through polymerization or condensation at high temperatures. Or the bonds may be made when practically all the solvent is out as with "contact" adhesives.

In wet assembly, relatively low pressure is required while curing, and it is easy to obtain accurate alignment if mistakes in position are noticed before the adhesive sets. In addition, no floor space is needed for drying of adhesive-coated parts being prepared for assembly. On the other hand, pressure jigs may be necessary during curing, and on large operations, the amount of floor space involved can be substantial.

Contact Bonding

This method requires only the application of pressure to adhesive-coated surfaces to accomplish the bonding. With contact adhesives, coating of only one surface is usually required.

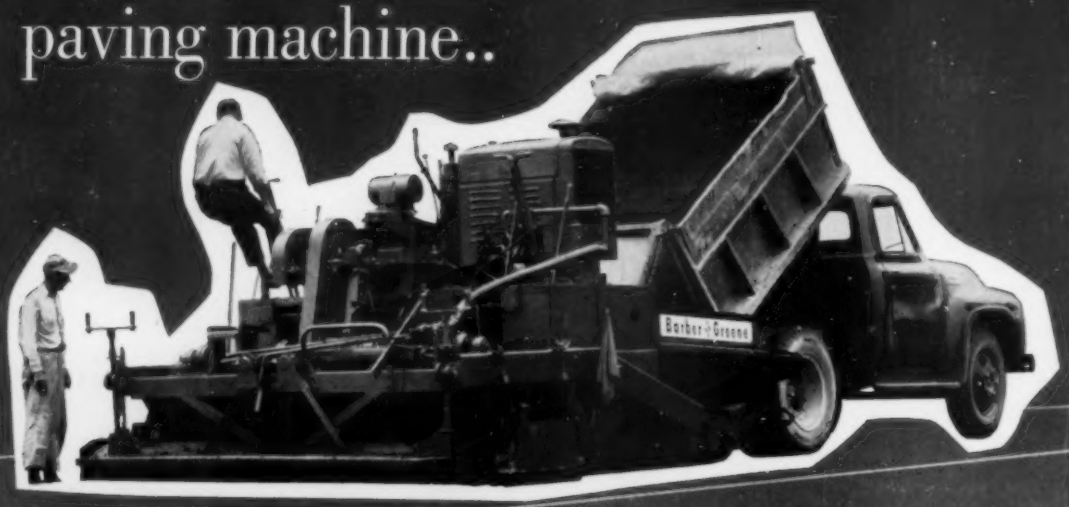
Contact adhesives, with inherently higher strength than softer, truly pressure-sensitive products, generally work best when both surfaces are coated. However, if the adhesive is applied to only one surface, more solvent must be present in the film at the time of assembly to permit transfer of the adhesive. With Buna-N, neoprene, and reclaim-rubber adhesives, there is generally enough residual "tack" in the films after solvent evaporation, but tack range varies with each adhesive.

In joining nonporous surfaces, both surfaces should be coated, and the maximum amount of solvent should escape before assembly. Where one of the surfaces is permeable, however, the adhesive films need not be so dry. In bonding impervious materials with adhesives that lack adequate tack range for easy assembly, an inter-liner of cotton duck or chipboard will help the volatile material to escape. Then, the adhesive can be used in a softer condition than permissible where no volatile escape is possible.

Generally, contact adhesives develop a reasonable bonding strength as soon as assembly is completed. Pressure requirements are usually low —often a hand roller will do the job —and pressure need be applied only long enough to ensure full contact.

:. for strength
.. for accuracy

16 important operating PARTS of this Barber-Greene paving machine..



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STRESSPROOF makes a better part at lower cost.

If you make parts requiring ground and polished accuracies or finish, plus these in-the-bar qualities . . (1) High Strength, without heat treating, double that of ordinary cold-finished shafting, (2) Machinability, fully 50% better than heat treated alloys of the same strength, (3) Wearability, without case hardening and (4) Minimum Warpage . . then STRESSPROOF offers you definite advantages. Write or call for further information.

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Perspectives

IN DESIGN AND DEVELOPMENT

THE INDUSTRIAL DESIGNER AND THE ENGINEER

"Ideally, the industrial designer and the design engineer ought to be the same man. But nowadays these qualifications are rarely found in one person. There is just too much for any one man to know. The result is that we are all specialists working within our limited sphere. Although the separation of industrial design and design engineering is not inevitable, more and more firms are beginning to find it practical to define them as separate functions." Such is the opinion of Henry Dreyfuss, successful industrial designer who has been in the business for 25 years, actually, about the age of the profession itself.

STILL AN UNKNOWN PROFESSION

But as successful as the industrial design profession is, it is scorned by many engineers and businessmen, and misunderstood by a lot more. Even now, many businessmen do not know what an industrial designer is or does or how he can help a company. Many shy away from an industrial designer because he might have a bad effect on the morale of his engineers.

The product designer is responsible for the inner workings of the product, and the industrial designer is responsible for what the purchaser looks at and touches when he sees the product. Basically then, the industrial designer is a salesman who helps the product sell itself by giving it an appearance that shows to advantage the features that the design engineer has built into his product. But beyond this simple definition, the industrial designer is concerned with function: he helps give the product a final form that can be manufactured efficiently and at a reasonable cost, sold at an acceptable price, used conveniently and safely, and easily maintained. In spite of this, the comment is frequently heard, "Why do I need an industrial designer? I can get any artist to spruce up my product." This is where many companies go wrong. The industrial designer always keeps in mind that the product has to be used as well as looked at.

HE IS PART OF A TEAM

The industrial designer is the first to admit that he can function only as part of a team, and that he needs the cooperation and confidence of the product designer. This seems easy to say. But it is at this point where the difficulty, if any, will arise. Many an engineer will resent the intrusion of the industrial designer, for he will think that his abilities are being questioned; or worse, that the industrial designer is out to take over his job. Such is not the case, of course. But the industrial designer still must be a first class diplomat to convince the engineer of this.

"Having been in this business for quite some time," says Mr. Dreyfuss, "I feel that I can say with some certainty that the conflict is rarely the fault of either the engineer or the industrial designer. In those cases where conflict has occurred—and they have been a drop in the bucket compared with the number of smooth relationships—the responsibility most often

(Continued on page 131)

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polystyrene bandsaw cover made lighter, stronger, at lower cost...

An important feature of this new Magna 11" Bandsaw is its injection-molded styrene cover. It's lightweight – important to the operator who must remove the cover to change blades . . . it's strong and sturdy. Here's product enhancement . . . at a saving; for it costs less than a die cast part.

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CHICAGO MOLDED PRODUCTS CORP.

1032 N. Kolmar Ave., Chicago 51, Illinois

rests with management. I've said that engineers and industrial designers work best as a team. Conversely, they work least efficiently when they function as isolated groups. I can't think of an easier way to antagonize a design engineer than to call in an industrial designer after the product has been designed. The industrial designer is forced into the position of sitting in judgment on the engineer, and may initiate some major changes. In such a case he has a difficult time in gaining the engineer's respect. To do a complete job the industrial designer should be called in when the product is in the talking stage."

A DIFFERENT PERSPECTIVE

Perhaps the main reason given by a company for hiring an industrial designer is that he brings an entirely new perspective to the design problem. Certainly the old saying: "He can't see the forest for the trees," applies to many a company engineer after he has worked on a problem for a long time. His view is close-up, while the industrial designer sees it from a distance. Combine the two and a good all-around product design results.

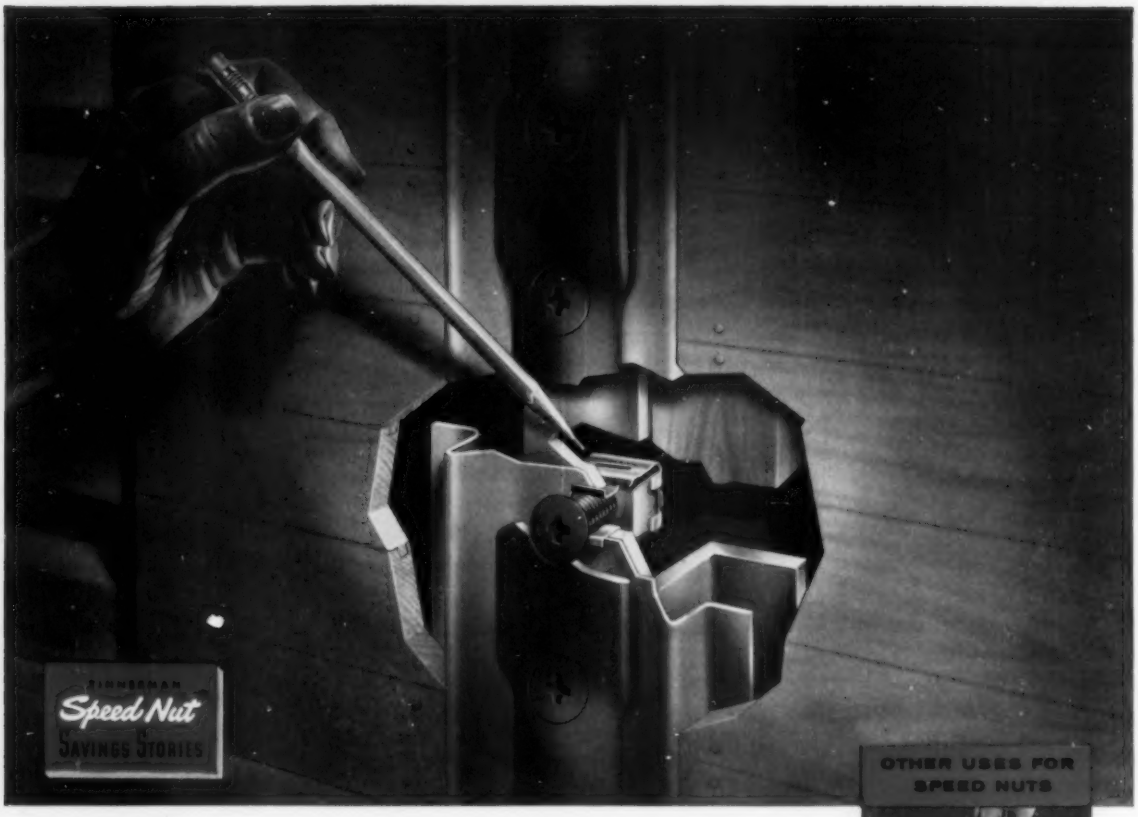
LOOKING FOR AN INDUSTRIAL DESIGNER?

In searching for a competent industrial designer, the manufacturer should look for a man who: has an understanding of the client's problem; knows what the public wants and is familiar with merchandising methods; has a knowledge of manufacturing and production methods and labor relations; knows how to meet a schedule; is willing to cooperate with the employer's personnel. Along with this goes the industrial designer's talent as an artist with an understanding of form, line, color and proportion.

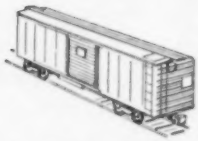
Mr. Dreyfuss says that in his office, design follows the following five-point formula: Convenience of use, including safety; Ease of maintenance; Costs (tooling and general manufacturing costs, and distribution problems); Sales (merchandising knowledge, public acceptance, and awareness of competition); and Appearance, where the designer adds his knowledge of form, line, proportion and color to present a good looking product.

HOW MUCH?

The industrial designer sells a design service, not a tangible product, and the value of his time is determined by experience, past performance, and reputation. He prefers to work on an Annual Basis arrangement which covers a complete line of the company's products. Payment can be made in the form of a monthly retainer fee, plus time and expense, or as a flat inclusive retainer on an annual basis. Time costs are usually handled on a predetermined hourly rate for each designer, draftsman, modelmaker, or researcher. The Flat inclusive retainer can be arranged after the designer has worked with the client over a considerable period. Some clients prefer this because they know what their design budget will be for the year. Work is done on a Specific Job basis when there is a particular job to be done and it is not expected that any further industrial design advice will be needed. Sometimes the designer works on a royalty basis and receives a percentage of the sales price of the article he has designed.



Box-car-size stresses are no problem for Tinnerman SPEED GRIPS®!



A new Lading Strap Anchor developed by the Pullman-Standard Car Mfg. Co., Chicago, is attached to guide plates by Tinnerman SPEED GRIP Nut Retainers. This anchor now makes it possible for shippers to fasten heavy loads in box cars without nailing or shoring. SPEED GRIPS were selected to make these heavy-duty attachments because no other fastener offers so many advantages for blind-location assembly.

SPEED GRIPS are the most efficient method of attaching square nuts to panels. Welding, clinching, staking are eliminated. No special skills or tools are required. SPEED GRIPS snap quickly, easily into panel holes, hold themselves in bolt-receiving position after the guide plate is attached to the box car side. They're rustproof, can be applied after painting, eliminating costly masking or retapping of paint-clogged threads. What's more, the nut "floats" in its spring steel cage to help correct normal misalignment in mounting holes!

Find out about the complete line of SPEED GRIPS and more than 8,000 other SPEED NUT brand fasteners. See your Tinnerman representative soon or write to us.

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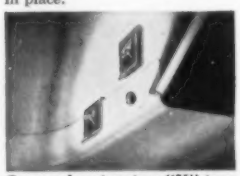
OTHER USES FOR SPEED NUTS

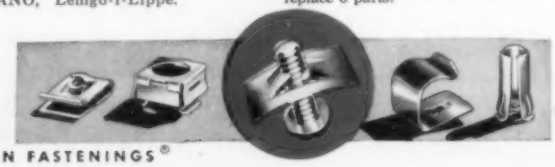
Snap-on SPEED CLIP® cuts costs by replacing 4-piece screw clamp to hold fractional-h.p. motors in place.



On garden tractor, "U" type SPEED NUTS make heavy-duty attachment of hood to yoke, cut assembly costs, parts handling.

Appliance thermostat control is assembled faster, easier, at less cost as 2 special SPEED CLIPS replace 6 parts.

TINNERMAN *Speed Nuts*®
FASTEST THING IN FASTENINGS®



The Open Mind Contradicts

DESIGN ENGINEERS MUST HAVE THE ABILITY to change their decisions and opinions whenever new developments so dictate. This principle applies in all fields of human activity. Indeed, much progress in science and technology involves altering scientific concepts or even discarding some. The members of the profession must repeatedly "change their minds" to keep in step with new developments.

Many people have a strong desire to cling to the old. Of greater significance, few lay people care to admit that what they had held to be correct is now wrong. But in the scientific professions, it is considered a mark of true greatness for a man to reverse himself when new data and knowledge indicate that his previously announced principles have been found to be in error.

On the design level there are innumerable instances in which the engineer finds himself in a position where he should drastically change his design concepts and principles. Failure to do so might be costly. He must overcome the urge not to admit what might seem to others to be a mistake. Also, there is always the fear of appearing to be vacillating.

Every new design is an excursion into the unknown, to some extent at least. Some of the problems involved will have to be solved by trial and error. Empirical design, which is not always satisfactory, must be used for some of the elements. Pet design ideas may prove to be impractical or wrong.

As a design progresses, decisions must be made promptly and positively. Often there must be some "back tracking." Every step in the design must be taken intelligently and with maximum data to support it. And the designer must have the courage to modify the design when new data or tests call for it.

It requires an open mind to be a good designer. The open mind is a flexible one. It is quick to conform to new scientific principles and precepts. It has no nostalgic yearnings for the irretrievable past. It does not blindly adhere to "sacred" fundamentals. It has the courage to appear to be contradictory, though in fact it is but forging ahead in step with progress.

George F. Rodenhoff

FACTS about NEW DEPARTURE BALL BEARINGS

aircraft turbine bearings . . .

DESIGNED for HIGH SPEEDS, LOADS and TEMPERATURES

New Departure split inner ring bearing mounting for jet engine main shaft

Today's leading production jet engines turn on New Departure split inner ring bearings . . . an out-ahead development of New Departure's continuing Aircraft Research Program.

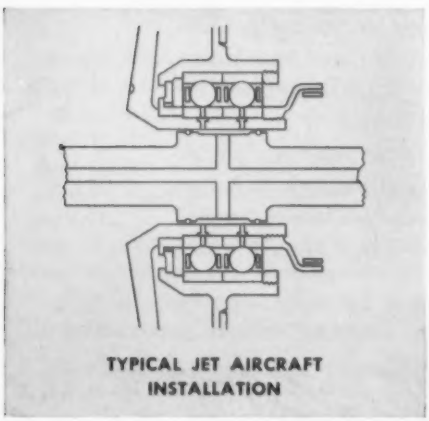
These turbine bearings handle heavy thrust loads from either direction and major radial loads with unexcelled dependability. Two-piece inner ring construction facilitates cleaning, inspection and assembly. It also permits use of the maximum number of balls of largest possible diameter with high thrust shoulders and one-piece separator construction.

While these bearings meet today's demand, tomorrow's needs command the facilities of the New Departure Aircraft Research Program. Already bearing development looks ahead to operational speeds in the order of 100,000 rpm and temperatures close to 1000° F. Write for New Departure's Aircraft Turbine Ball Bearing Folder TB-56. New Departure, Division of General Motors, Bristol, Connecticut.

MEDIUM and LARGE TURBINE BEARINGS

Basic Bearing No.	NOMINAL DIMENSIONS		
	Bore	O.D.	Width
LL34	6.6929	9.0551	1.102
LL36	7.0866	10.2362	1.614*
LL44	8.6614	12.5984	1.929*
L22	4.3307	7.0866	1.280*
L24	4.7244	7.4803	1.280*
L26	5.1181	7.8740	1.280*
L28	5.5118	8.6614	1.574*
L30	5.9055	8.5060	1.235*
L32	6.2992	9.4488	1.338
L34	6.6929	10.6299	1.815*
207	1.3780	2.8346	.669
209	1.7717	3.3465	.938*
212	2.3622	4.3307	.866
213	2.5591	4.7244	.905
214	2.7559	5.1181	1.023
215	2.9528	5.1181	1.181*
216	3.1496	5.5118	1.023
219	3.7402	6.6929	1.259
220	3.9353	7.0886	1.385*
222	4.3307	7.8740	1.771*
224	4.7244	8.4646	1.850*
228	5.5118	9.4488	2.007*
232	6.2992	10.1992	1.660
307	1.3780	3.1496	.826
315	2.9528	6.2992	1.456

*Puller groove, inner ring or both rings



TYPICAL JET AIRCRAFT INSTALLATION

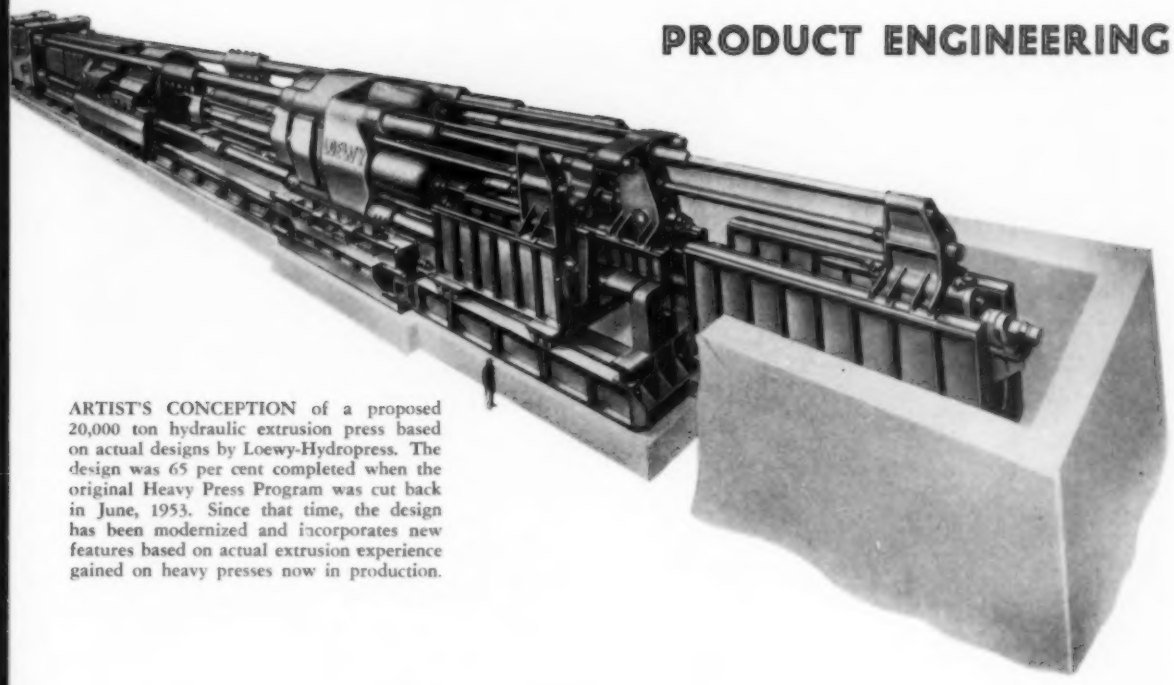
SEE "WIDE WIDE WORLD" SUNDAYS—NBC-TV

NEW DEPARTURE BALL BEARINGS

GM GENERAL MOTORS

NOTHING ROLLS LIKE A BALL

BALL BEARINGS MAKE GOOD PRODUCTS BETTER



ARTIST'S CONCEPTION of a proposed 20,000 ton hydraulic extrusion press based on actual designs by Loewy-Hydropress. The design was 65 per cent completed when the original Heavy Press Program was cut back in June, 1953. Since that time, the design has been modernized and incorporates new features based on actual extrusion experience gained on heavy presses now in production.

A REVIEW OF THE Heavy Press Program

JOHN ALICO, P. E.
on the staff of
T. J. Kauffeld, Consulting Engineers, New York, N. Y.

THE U. S. AIR FORCE-SPONSORED HEAVY PRESS PROGRAM is virtually complete and most of the big presses have been in operation long enough to produce definite results. The program, as it stands, is a success but it is not adequate to meet the needs of American design engineers and manufacturers.

Why the Program Was Initiated

Intelligence information acquired late in World War II indicated that the Germans had developed some unusual method of aircraft fabrication based, in part, on the use of heavy presses. As a result of this information, the first big press, of 18,000-ton capacity, was built in the United States.

On-the-spot investigation after the war revealed just how far ahead the Germans were in this field. Several 15,000-ton forging presses had been in operation since 1938 and one 33,000-ton unit was built and used during the war. At this time, the biggest closed die forging press in the United States was approximately 6,000 tons. The first step in closing the gap in this respect was the shipment of two 7,000-ton and two 16,000-ton forging presses from Germany to the United States as war reparations material.

The German 33,000-ton forging press fell into the Russian Zone and was moved to the Soviet Union where it is undoubtedly being put to effective use. Up to 1955, this press was the world's largest forging unit. In 1955, however, the American heavy press program put this country back in the lead with two 35,000 and two 50,000-ton forging presses and six extrusion presses going up to 14,000 tons in capacity. The program of increasing our national capacity in a field vital to air superiority was undertaken by the Air Force rather than private industry because of the tremendous size and cost of the program and also because the only foreseeable firm requirements were for the military.

Current Status of the Program

The original heavy press program called for the construction and operation of some 17 units, both extrusion and forging presses. This was cut back to 10 units; 6 extrusion presses and 4 forging presses. The extrusion press installations are outlined in Table I, while Table II lists the forging press plants.

Heavy extrusion presses are being used to produce long, massive sections, Fig. 1, that cannot be rolled. Long continuous sections which previously could only be produced by machining or hogging out bar stock can now be extruded at considerable savings. These presses, moreover, are used to extrude forging stock for the heavy forging presses which results in the generally higher properties of an extruded section in a forged part.

The 35,000-ton and 50,000-ton closed die forging presses are piling up long-term backlogs of work as a result of successful operations on parts which had not been producible heretofore. One of these parts, Fig. 2, is a 262 lb aluminum alloy piece which measures 125 in. long. Another heavy forging is a 474 lb beam whose overall dimensions are 91 in. long, 18 in. wide and 10 in. thick.

Basic premise in support of the original heavy press program has been fulfilled. This premise called for the means to produce larger and stronger structural components required by the increases in size, weight, speed and range of modern aircraft, both commercial and military. The heavy presses are now turning out these components but their potential production is by no means limited to aircraft.

Early Heavy Press Design Problems

Original specification required that the heavy presses be "producible, transportable, and operable." These conditions set up problems which made it necessary to review

Table I—Heavy Extrusion Press Installations

Operator	Location	Press Unit Installed	Material Extruded	Current Status
Aluminum Company of America	Lafayette, Ind.	1—14,000 ton Schloemann	Aluminum	In production
Kaiser Aluminum & Chemical Co.	Halethorpe, Md.	2— 8,000 ton Loewy	Aluminum	In production
Harvey Aluminum	Torrance, Calif.	1— 8,000 ton Loewy	Aluminum	In production
		1—12,000 ton Loewy	Aluminum	Scheduled operation Fall, 1956
Curtiss-Wright Corp.	Buffalo, N. Y.	1—12,000 ton Loewy	Steel and Titanium	In production

Table II—Heavy Forging Press Installations

Operator	Locations	Press Unit Installed	Material Forged	Current Status
Aluminum Company of America	Cleveland, Ohio	1—35,000 ton United	Aluminum	In production
		1—50,000 ton Mesta	Aluminum	In production
Wyman-Gordon	North Grafton, Mass.	1—35,000 ton Loewy	Aluminum and Magnesium	In production
		1—50,000 ton Loewy	Aluminum and Magnesium	In production

Fig. 1—Representative sections extruded on a regular production basis by heavy presses designed by Loewy-Hydropress Div., Baldwin-Lima-Hamilton Corp. The wide variety of shapes made possible by the extrusion process presents an opportunity to convert built-up sections into a single piece; die circle for 8000 ton press is 13 in.

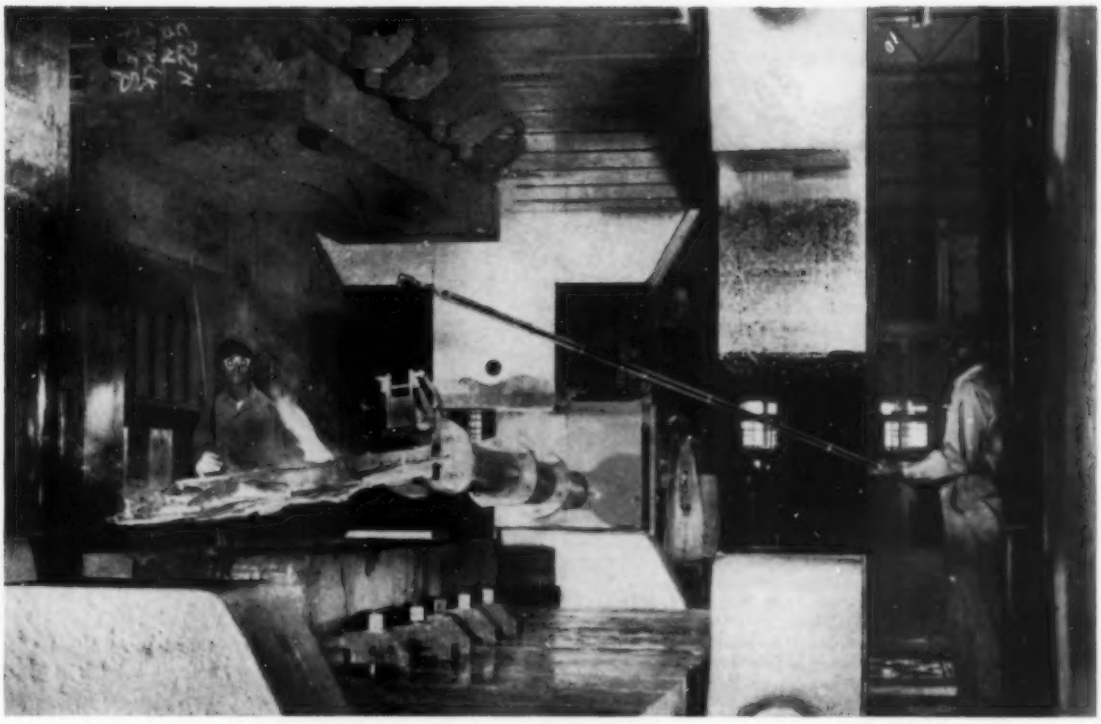


Fig. 2—A wing spar forging is being removed from one of the heavy presses in the U. S. Air Force plant at Alcoa's Cleveland, O., works immediately after the first "blocking" or forging squeeze has been performed. The workman holding the long spray pipes is applying lubricant to the forging dies.

the criteria of design in terms of (1) availability of manufacturing facilities, (2) permissible eccentricity of forging, (3) the production of forgings with the desired dimensional accuracy so that press parts could be designed within the tolerances required, and (4) availability of cars and routes to permit shipment of the press components from the manufacturer to the erection site.

There were other problems such as availability of machine tools to produce the forging dies and extrusion press tools such as containers and stems. Then, too, there was the problem of providing power for the presses. On the metallurgical side, there was the problem of supplying homogeneous material for the presses as well as devising ways of producing large billets for the extrusion presses and rolled stock for the forging presses.

Availability of Manufacturing Facilities

Facilities available in the United States were capable of producing every part required by the heavy press program. Expediency, however, dictated the need to explore other manufacturing facilities over the free world. At the time that contracts were released to the press suppliers, much of America's capacity was already committed to the Korean crisis.

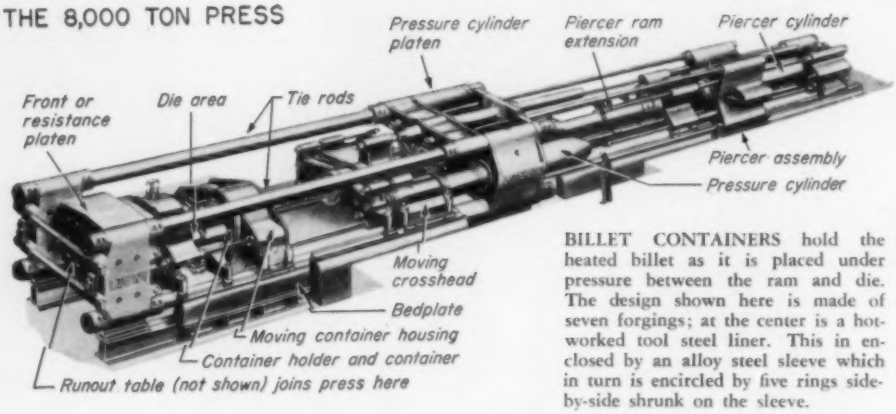
It was prudent in the light of the program's early completion target dates to place some of this business in countries being aided by the Marshall Plan. Heavy press parts were all designed in the United States (with the exception of the Schloemann 14,000-ton press set up at Alcoa's Lafayette, Ind., plant) but some of them were made in England, Germany, France, Italy, Canada and Japan. For example, the containers into which the forging press cylinders were inserted were produced in Japan; these weighed about 35 tons each. The four crossheads for the Loewy 35,000-ton forging press, weighing about 180 tons each, were cast in England.

Designing Against Excessive Eccentric Loads

Secondary stresses set up by eccentric forging may easily exceed the primary stresses due to central forging. This problem was recognized and heavy forging press specifications called for full pressure to be exerted ± 2 ft off center along the long axis of the press, and ± 1 ft off center in the lateral direction. This meant that proper provision had to be made for an eccentric moment equal to twice the press capacity in ton-ft in addition to the full central pressure of the press. The 35,000-ton press, for instance, was designed for a 70,000 ton-ft eccentric moment in addition to the full central pressure of 35,000 tons.

One successful method of protecting the press against excessive eccentric loads which would cause damage to either the main tie rods or to the press structure itself, utilizes a hydraulic force-compensating system. The action of this system is fully automatic and the degree of load compensation is a function of the rotational deflection of the upper entablature of the press when it is sub-

THE 8,000 TON PRESS

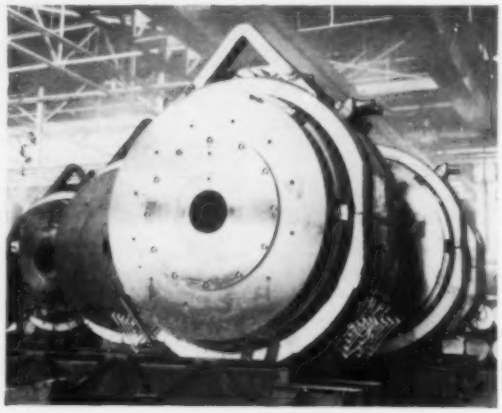


BILLET CONTAINERS hold the heated billet as it is placed under pressure between the ram and die. The design shown here is made of seven forgings; at the center is a hot-worked tool steel liner. This in enclosed by an alloy steel sleeve which in turn is encircled by five rings side-by-side shrunk on the sleeve.

Cover picture on this issue shows an alloy steel billet container assembly built by Bethelehem Steel being readied for shipment. This assembly was designed for use in the two 8000-ton extrusion presses in the Air Force Heavy Press Plant installation at Halethorpe, Md. The container assembly with its outside heating equipment weighs 41 tons, and has an outside diameter of more than 6 ft.

These presses were designed and built by Loewy-Hydropress Div., Baldwin-Lima-Hamilton Corp. Each one weighs 1500 tons and has 3 pressure stages; 2800, 5400 and 8200 tons. They can accommodate round aluminum billets up to 20 in. in diameter by 55 in. long, and rectangular billets 6 in. high by 33 in. wide by 30 in. long.

Maximum operating pressure is 4500 psi supplied by an air-hydraulic accumulator. A piercer attachment permits the extrusion of hollow shapes over a mandrel. The overall dimensions without the runout table are 120 ft long by 18 ft wide and 20 ft high.



Presses and auxiliary equipment are housed in a plant of 316,000 sq. ft; total cost of buildings and equipment is over $30 million. The plant is operated by Kaiser Aluminum & Chemical Corp. under a lease arrangement.

jected to an eccentric loading during an extruding cycle.

The eccentric load compensating system is designed to compensate for a compound eccentricity, co-ordinate to the center of the press platens. In addition to the compensating system, an automatic strain-gage protective system has been incorporated into the press. The strain gages are mounted permanently on the main tie rods of the press. When preselected values of strain in the tie rods are exceeded, the hydraulic system is unloaded automatically thus preventing damage to the press.

The extremely large eccentricities specified by the Air Force for the heavy forging presses, far exceed the conventional limits, thus building into the presses a flexibility which is proving advantageous in meetng new developments, both industrial and military.

Design of Press Parts

Each manufacturer had his own solution to the design of press parts so that maximum dimensional accuracy could be achieved. Loewy abandoned the cylindrical column and used an assembly of laminated rectangular shapes. The reasons for going to this design was to eliminate threads and be rid of stress concentration, notch sensitivity and the possibility of residual stresses caused by machining. The problem of stress distribution in the supporting surfaces was encountered in the new design but photoelastic tests proved conclusively that the loading could be absorbed properly.

United uses cylindrical columns in its 35,000-ton press. The press has eight columns set up in four 2-column units which, according to United, permits full proportional

stressing of all columns–the units being free to stretch vertically independently of one another, yet keyed and bolted against lateral movement. The columns are 34 in. dia and 61 ft long, made of forged steel and bored; the main fluid medium for the hydraulic system flows through the column which acts as a pipe as well as the main tension unit of the press.

Mesta, too, uses cylindrical columns finished to a dia of 40 in. and a length of 76 ft. Each column was trepanned full length to remove a 6 in. dia core.

Because each manufacturer had his own design philosophy, the presses take on an individuality which becomes apparent when one looks at them. All of the forging presses are in production and it will not be too long before sufficient data will have been recorded to provide the basis for improvements in presses of greater capacity.

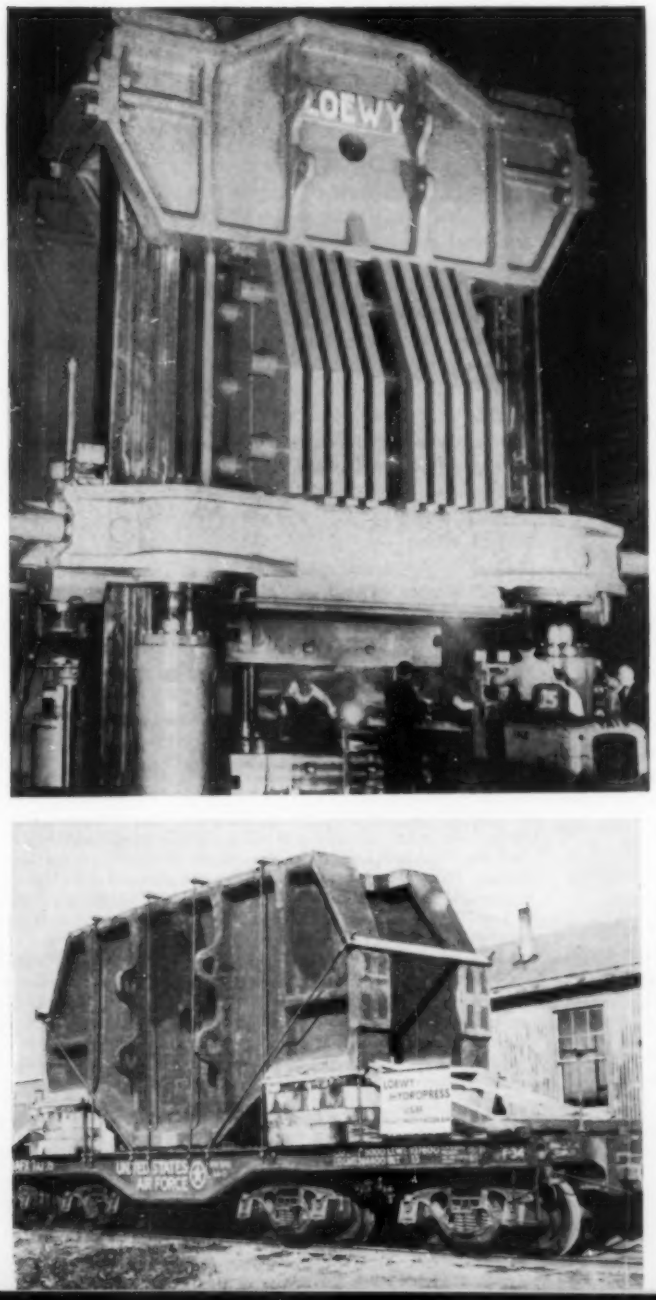
Transportation of Parts

Press capacities precluded the use of many small parts tied together in some form. Obviously some of the parts would be too big to be transportable by standard means. It was necessary, therefore, to make special studies of each press to determine the best method of transporting the unusually large pieces.

Water transportation was used wherever possible but overland transport provided many problems. Trucks could not be considered for the big parts and its was necessary not only to follow certain tunnelless, wide-clearance rail routes but to schedule movement so that there would be no possibility of accident.

In addition to this planning, special rail cars had to be built to provide depth for head clearance and length for turning clearance. How part of the problem was solved is shown in Fig. 3 for one press.

Fig. 3—The steel casting shown on a special-built flat car weighs 180 tons and is the cradle shown on top of the 50,000 ton forging press built by Loewy-Hydropress.



Special Machine Tools Required

As the program got under way, designers of parts to be produced on the heavy presses encountered another problem. Could die blocks and the machine tools necessary to make dies be obtained in time to permit "freezing" the design? This would make production of the ultimate assembly, whether it was an airplane or other material, dependent upon some very close scheduling.

The size of the presses meant larger dies than had ever been made before. This in turn meant larger die blocks and larger machine tools. The production of forging dies is a combination of design, die sinking, and die tryout. The largest die-sinking machines ever built became an essential part of the heavy press programs. These machines, despite their size are capable of producing precise impressions from plaster models of the forging.

As die blocks get larger there is a tendency for them to be somewhat less sound and uniform towards the center. To overcome this defect and thus eliminate waste in material and machine-hours of work, die block producers are using sonic inspection methods to check the soundness of each die blank.

The matter of sound material is also important in extrusion press tools. These tools present a severe test for steels since

they must retain their strength at the relatively high extruding temperatures while subject to high stress, abrasion, and shock loads.

The essential extrusion tools, comprising dies, mandrels, dummy blocks, back-up pieces and container liners are fabricated from heat resistant steels. The material usually used for these applications are of the tungsten-chromium type, with 1 to 15 per cent tungsten and 1 to 12 per cent chromium and smaller additions of nickel, molybdenum, manganese, vanadium or silicon, depending upon the alloy being extruded or the tool being used.

Extrusion Press Dies

Problems in design of extrusion press dies become greater with the heavy presses. The magnitude of the variations in metal flow characteristics grows as ingot size or section size is increased. The usual extrusion die for a solid shape has a flat working face and the designer strives for a uniform flow of metal through the die opening. When non-uniform flow is involved certain compensating factors may be used. These include varying the arrangement of the opening on the die face, providing extra width of opening for portions of the shape, and adjustment of the bearing length in various portions of the die. Normal bearing lengths for simple extrusions vary from $\frac{1}{16}$ in. to $\frac{3}{8}$ in., but for intricate and large extrusions, bearing lengths in the large opening portion of the die may be several inches. The amount of bearing length can be found only by empirical means.

Spider, bridge or portable dies are used to produce hollow shapes or tubes from solid ingots. In their operation, the solid ingot is parted into two or more streams of metal which are rewelded in the die over a mandrel, thus producing a hollow shape. The advent of the heavy presses offers a means of increasing the use of these types of dies.

The production of stepped extrusions is almost an exclusive development with the heavy presses. There should be an increasing use of this type of extrusion because the stepped or "blob" end can be forged and the resulting part—a combination extrusion and forging—certainly should find many industrial applications.

Extra Large Billet Production

Because 9 out of the 10 heavy presses are designed for aluminum, some mention should be made of the solution to the problem of producing suitable aluminum billets and ingot for these units. The aluminum alloy ingot used for extruding or forging should be as uniform as possible in chemical composition with a fine grain structure. The ingot should be free from cracks, splits and harmful porosity and clean with respect to non-metallic inclusions.

The D-C (direct-chill) process was selected for development of casting large ingots. In this process, molten metal is introduced at a controlled rate into a water-cooled mold. The partially solidified ingot is lowered past the mold, again at a controlled rate, through direct water sprays. The top of the molten metal is 3 in. above the bottom edge of the mold and this distance is called the "head." The head is kept constant by means of a flow regulator rod placed inside the pouring nose, or spout, which is adjusted above the pouring trough to regulate the amount of molten metal introduced into the mold. A bottom block is used to close the bottom end of the mold at the start of casting and supports the billet as it is lowered. The block, in turn, rests on an hydraulically actuated table.

Square, rectangular and round billets may be produced by the D-C process simply by using the required mold, the form of the sprays and the shape of the bottom block. Hollow round ingot for extrusion can also be produced by this process using the same set-up for casting a solid round ingot except that an internally water-cooled tapered core is used along with an annular bottom block. The tapered core is the same length as the mold, and the water cooling the core also cools the inside surface of the hollow ingot being cast.

By using the D-C process, strong aluminum alloy extrusion ingots up to 32 in. dia and weighing up to 8000 lb are successfully cast. Rectangular ingots 28 in. thick by 45 in. wide and weighing up to 12,000 lb are cast for pressing or rolling prior to being forged in the heavy presses.

The Next Phase—Heavier Presses

With the current program serving as a firm foundation for projected expansion in press capacity, American industry can supply and use a 20,000 ton extrusion press. Sufficient know-how has been gained so that a 20,000-ton press can be designed. Insofar as auxiliaries are concerned, billet casting facilities, billet preheating furnaces and stretcher equipment need to be expanded only slightly to accommodate the production required of a 20,000 ton extrusion press. The gap between the existing 14,000-ton and a proposed 20,000-ton unit is not so great when it is realized that the billet diameters will differ only about 4 in. for aluminum. For the other metals, there will be the performance of the 12,000-ton press at Curtiss-Wright to use as a basis for extrapolation.

With 18,000, 35,000, and 50,000 ton closed die forging presses already in operation, the next logical step appears to be the design and installation of a 100,000-ton press.

The heavier presses should be able to produce bridge sections, large parts for railway cars, trucks and building construction as well as aircraft. That there is a commercial market for extrusions produced by the heavy presses is substantiated by the recent Alcoa announcement that they will purchase a 14,000-ton extrusion press with their own funds and thus make additional capacity available to designers of commercial products.

AUTHOR'S ACKNOWLEDGMENT—The data presented here comes from many sources and reflects the author's association with the Heavy Press Program from its inception to its conclusion. Notes from symposia held by the American Society of Mechanical Engineers in New York, Chicago and other meetings in Los Angeles, Washington and Wright Patterson Air Force Base were freely drawn upon and used.

I want to thank Mr. Erwin Loewy, president of Loewy-Hydropress Div., Baldwin-Lima-Hamilton Corp., for making available the various pictures and data. Mr. John L. Lebach of his organization was particularly cooperative in supplying material which was used here. I am also grateful to Mr. Alexander Zeitlin, formerly of Loewy-Hydropress and now with Birdsboro Steel Foundry & Machine Co., for his help in this project.

For a review of earlier articles in *Product Engineering* reporting and discussing the Heavy Press Program see note in August 1955 on page 153, and December 1955 page 198.

Nomograph for Designing Gas Nozzles and Orifices

Alignment chart gives weight of flow if pressure ratio, upstream pressure and orifice diameter are known.

SYMBOLS

A — Area
C_d — Discharge coefficient
C_p — Specific heat at constant pressure
d — Diameter of nozzle or orifice
E_I — Internal energy
E_K — Kinetic energy
EP — Potential energy
E_W — Work
E_{FW} — Flow work
g — Gravitational constant of acceleration
h — Enthalpy
J — Joule's constant
k — Specific heat ratio or process exponent
P — Absolute pressure
Q — Transferred heat
R — Gas constant
T — Absolute temperature
U — Velocity of flow
V — Specific volume (volume per unit weight)
W — Gas weight flow per unit time

Subscripts 1 and 2 refer to states 1 and 2 respectively.

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THIS NOMOGRAM SOLVES PROBLEMS relating to nozzles and orifices used as flow controlling devices for compressible fluids. Pressure drop can be found if the weight of flow and diameter are known for a particular upstream pressure. While drawn up for aircraft and missile problems, with flow correction for gases other than dry air the nomogram may be applied to air conditioning and industrial problems.

Basis of nomogram is flow weight equation representing thermodynamic relationships for the ideal situation, and corrections are added for various nonideal configurations. A coefficient accounts for relative difference in efficiency between nozzles and orifices.

DERIVATION OF FLOW WEIGHT EQUATION

Basic Thermodynamic Relationships

1) First law of thermodynamics or the conservation of energy:

$$E_{P1}+E_{K1}+E_{FW1}+E_{I1}+Q=E_{P2}+E_{K2}+E_{FW2}+E_{I2}+E$$

2) Conservation of mass:

$$W = W_1 = W_2$$

$$W = \frac{A_1 U_1}{V_1} = \frac{A_2 U_2}{V_2}$$

3) Enthalpy:

$$h = \frac{E_I + E_{FW}}{W}$$

$$h = C_p(T_1 - T_2)$$

4) Kinetic Energy:

$$E_K = \frac{W U^2}{2gJ}$$

5) Specific Heat:

$$C_p = \frac{k R}{(k-1)J}$$

Assumptions

1) Change in potential energy is negligible compared to the other forms of energy within the system.
2) Transferred heat is zero, the flow process occurs so quickly that heat transfer is not possible. The adiabatic flow equation is modified by a constant because real nozzles and orifices differ slightly from those computed with adiabatic flow relations.
3) Work done by the substance is zero.
4) Velocity of flow upstream is zero. (Correction derived later accounts for initial velocity not equal to zero.)

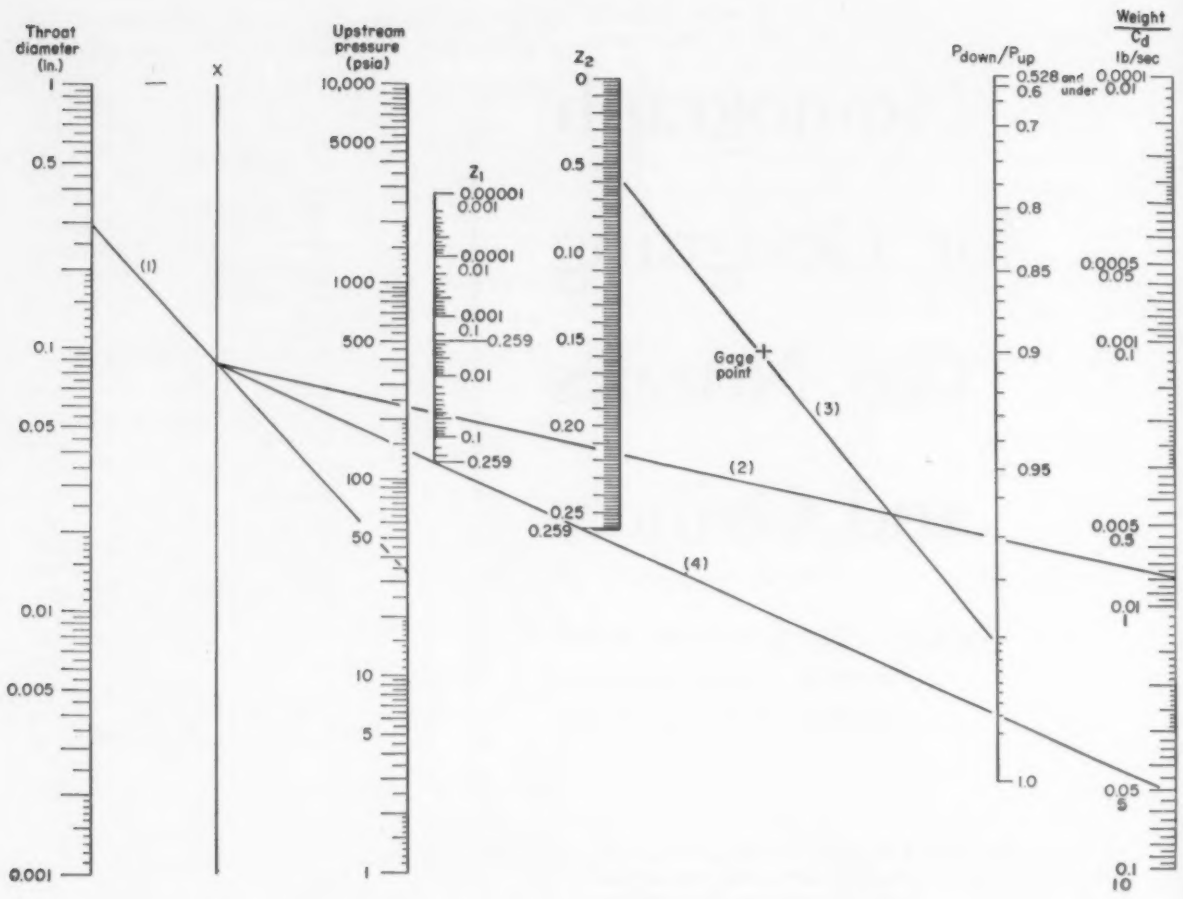
Equation Derivation

When the above assumptions are used to amend the energy balance equation, there results:

$$Wh_1 = \frac{W U_2^2}{2gJ} + Wh_2$$

Solving for U_2 (one pound of gas):

$$U_2 = \sqrt{2g J (h_1 - h_2)}$$



The weight of flow passing through the device can be expressed as:

$$W = \frac{A_2 U_2}{V_2}$$

Introducing the value for U_2 and noting that:

$$V_2 = V_1\left(\frac{P_1}{P_2}\right)^{\frac{1}{k}} = \left(\frac{RT_1}{P_1}\right)\left(\frac{P_1}{P_2}\right)^{\frac{1}{k}}$$

The weight of flow becomes:

$$W = \frac{A_2\sqrt{2gJ(h_1 - h_2}}{\left(\frac{RT_1}{P_1}\right)\left(\frac{P_1}{P_2}\right)^{\frac{1}{k}}}$$

Using the values for $h_1 - h_2$ or h, C_p, and

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$$

the weight of flow equation is changed to a more usable form:

$$W = A_2 P_1\sqrt{\frac{2gk}{(k-1)RT_1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{2}{k}} - \left(\frac{P_2}{P_1}\right)^{\frac{k+1}{k}}\right]} \frac{\text{lb}}{\text{sec}}$$

This equation is the weight of flow passing through a convergent nozzle under ideal conditions. For practical applications, add the coefficient:

$$W = C_d A_2 P_1\sqrt{\frac{2gk}{(k-1)RT_1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{2}{k}} - \left(\frac{P_2}{P_1}\right)^{\frac{k+1}{k}}\right]} \frac{\text{lb}}{\text{sec}} \quad (1)$$

(For values of C_d see Table I) State point 1 is the stagnation point or the state that upstream flow would be in if flow were instantaneously halted. Actually this is described by some ambient upstream condition undisturbed by flow. State point 2 is the location at the minimum diameter of a convergent nozzle or an orifice.

Nomogram includes these constant values:

$g = 32.174$ ft/ sec^2
$T_{upstream} = 519$ R (Equivalent to 59 F)
$k = 1.4$
$R = 53.3$ ft lb/lb − deg R

A simplified equation resulted, and was plotted as the nomogram:

$$W = .07084\, C_d\, d^2_{throat}\, P_{upstream}\, Z \quad (2)$$

where

$$Z = \sqrt{\left(\frac{P_2}{P_1}\right)^{1.428} - \left(\frac{P_2}{P_1}\right)^{1.715}} \quad (3)$$

CORRECTION FACTORS

Initial Velocity

For use when the effects of approach or initial velocity are not negligible. Considering the velocity of upstream flow not equal to zero, but keeping all other assumptions, the energy balance equation yields:

$$\frac{W U_1^2}{2gJ} + Wh_1 = \frac{W U_2^2}{2gJ} + Wh_2$$

From mass balance equation:

$$U_1 = \frac{A_2}{A_1} \cdot \frac{V_1}{V_2} \cdot U_2$$

Combining these two equations:

$$U_2^2 = \left[\frac{A_2}{A_1} \cdot \frac{V_1}{V_2} \cdot U_2\right]^2 + 2gJ\,(h_1 - h_2)$$

From which

$$U_2 = \sqrt{\frac{2gJ\,(h_1 - h_2)}{1 - \left(\frac{A_2}{A_1}\right)^2 \left(\frac{V_1}{V_2}\right)^2}}$$

Thus the correction multiplier is:

$$\frac{1}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2 \left(\frac{V_1}{V_2}\right)^2}}$$

In order to arrive at a more usable form it is desirable to change V_1/V_2 to a function of pressure or:

$$\frac{V_1}{V_2} = \left(\frac{P_2}{P_1}\right)^{\frac{1}{k}}$$

and the correction multiplier which should be applied to a nomogram solution becomes

$$\frac{1}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2 \left(\frac{P_2}{P_1}\right)^{\frac{2}{k}}}}$$

Temperature

The nomogram is based on an upstream temperature of 519 deg R (59 F). To obtain the flow weight for another upstream temperature, multiply the nomogram solution by a factor $\sqrt{519/T}$.

Gases Other Than Dry Air

The nomogram is directly usable for any gas with a gas constant of 53.3 ft/lb/lb – deg R. For any gas with a different gas constant, the weight of flow should be multiplied by $\sqrt{53.3/R}$. See Table II for values of R.

MAXIMUM WEIGHT OF FLOW

If the weight flow equation is differentiated with respect to the pressure ratio $P_{downstream}/P_{upstream}$ and equated to zero, maximum flow will occur when downstream pressure is 52.8 per cent of upstream presseure.

This downstream pressure is called the critical pressure. Any downstream pressure above critical pressure will reduce weight of flow, but any downstream pressure lower than critical will permit maximum weight of flow to continue. The latter property results from the fact that, at maximum flow, flow velocity is equal to sonic velocity or speed of a pressure surge through throat area. If the gas is flowing at pressure surge velocity, no indication of downstream pressure can reach the throat area.

In a convergent nozzle or an orifice, the velocity of flow will never exceed sonic velocity because of the resulting shock conditions. To exceed sonic velocity, a nozzle needs a section which will permit a smooth pressure transition, a divergent section. However, for ordinary restrictors such considerations are unnecessary.

SAMPLE PROBLEMS

Example 1: Upstream pressure through a $\frac{1}{8}$-inch, sharp-edged orifice is 3000 psig. (A) What is maximum weight rate of air that can flow through orifice? (B) What is downstream pressure? Solution: (A) Lay straight line across throat diameter scale at 0.125 ($\frac{1}{8}$ inch) and 3015 psia (3000+14.7) on upstream pressure scale. Then connect crossing point on X scale with maximum flow point on Z_1 scale (0.259 in red) by straight line. Weight/C_d scale gives 0.851 lb per sec for ideal nozzle. Multiply by 0.6 (Table I) to get actual flow of 0.516 lb per sec for sharp-edged orifice. (B) Downstream pressure will be $0.528 \times 3015 = 1590$ psia. Or, on nomogram, note 0.259 on max flow value (Z_1 scale). Lay straight line across 0.259 (Z_2 scale) and gage point. Then extend straight line to P_{down}/P_{up} scale, obtaining 0.528 as the desired pressure ratio.

Example 2: For orifice in Example 1, what is pressure drop if only 0.422 lb per sec of air is flowing, and upstream pressure is 3015 psia? Solution: 0.422/0.6 (Table I) gives 0.704 lb per sec as the ideal flow. Mark 0.704 on Weight/C_d scale. By straight lines connect 0.125 on throat diameter scale with 3015 on upstream pressure scale, and then the crossing point on X scale with the marked value. Read 0.21 on Z_1 scale, relocate to Z_2 scale, and connect with gage point by a straight line, giving 0.8 as the pressure ratio on P_{down}/P_{up} scale. Since $0.8 \times 3015 = 2410$ psia, pressure drop is $3015 - 2410 = 605$ psi.

Table I—Discharge Coefficients

Type of Nozzle or Orifice	Approximate Discharge Coefficient (C_d)
Thin Plate	0.6
Sharp Edged	0.6
Venturi	0.98
Long, Well Rounded	0.98
Borda (Inside Tube)	0.50
Short Tube	0.80

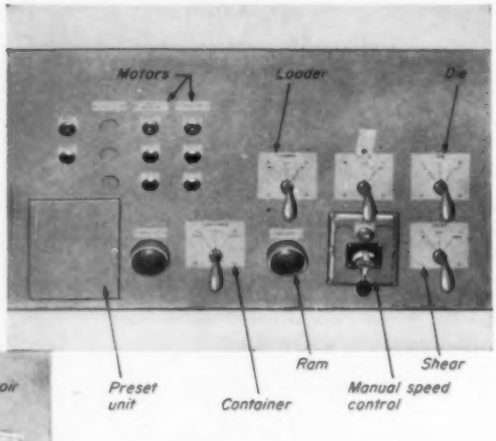
Table II—Gas Constants For Different Gases

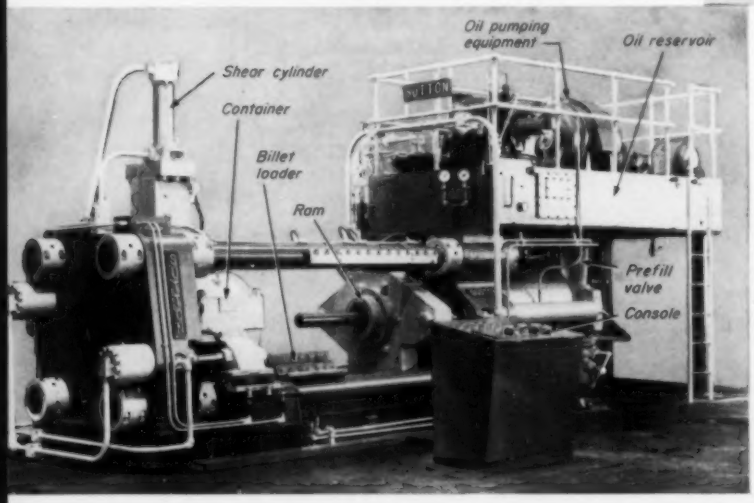
Gas	R	Temperature Range, deg F
Dry Air	53.3	−306 to +1040
Oxygen	48.31	−260 to + 540
Nitrogen	55.16	−260 to +1140
Hydrogen	766.8	−110 to +2140
Carbon Monoxide	55.19	−260 to + 940

Electro-Hydraulic Press Control Programs Extrusion Cycle

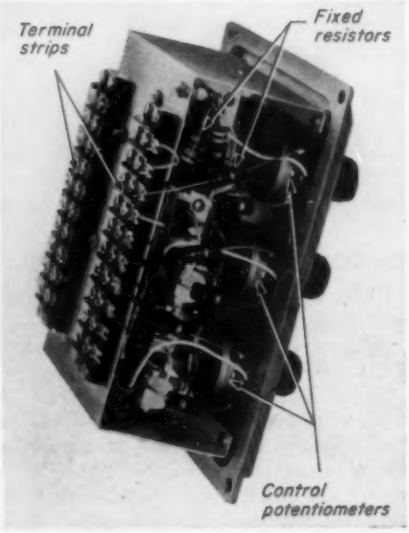
Electric controls and interlocks are combined with hydraulic power components to make an automatic cycle programming system for a 1500-ton aluminum extrusion press designed by the Hydraulic Department of Sutton Engineering Co., Bellefonte, Pa., under the direction of Walter Larson.

CONSOLE CENTRALIZES CONTROLS for starting pump motors and for manual and automatic operation of all press functions. Main circuit breaker is closed by "reset" button to energize press circuits as indicated by "ready" light. When in "safe" position, "safe-run" switch prevents motion of press elements while operator makes adjustments. Selector switches on panel are used for manual operation, and a "jog" button overrides all interlocks for out-of-sequence ram motions during set up. When set for automatic extrusion cycle, operator must press "ram-start" button before ram moves. The "emergency stop" button opens the main circuit breaker.

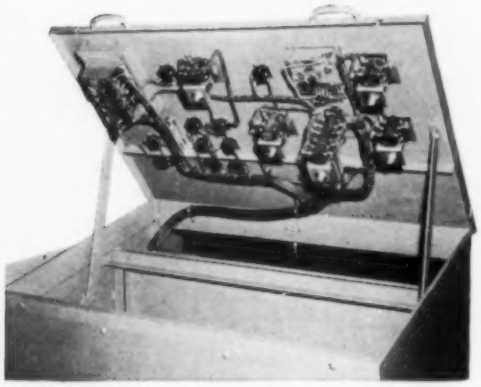




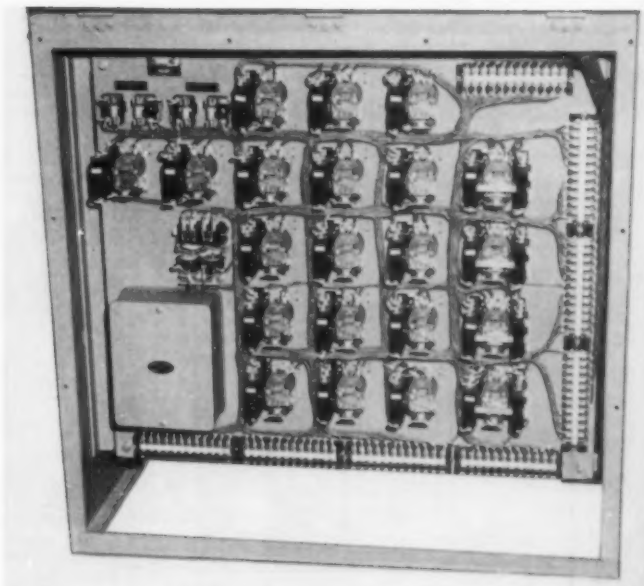
PRESET UNIT at lower left of panel has six potentiometers which set speeds sequentially selected by ram as its cam operates successive track switches. Preset speeds are: 1, rapid approach to billet handler; 2, slowdown to push billet and dummy block into container; 3, break through; 4, ram return; 5, extrusion; 6, a speed for manual operation not used on this press. Unit is made with electro-mechanical components which are small, lightweight, reliable, and easily mounted.



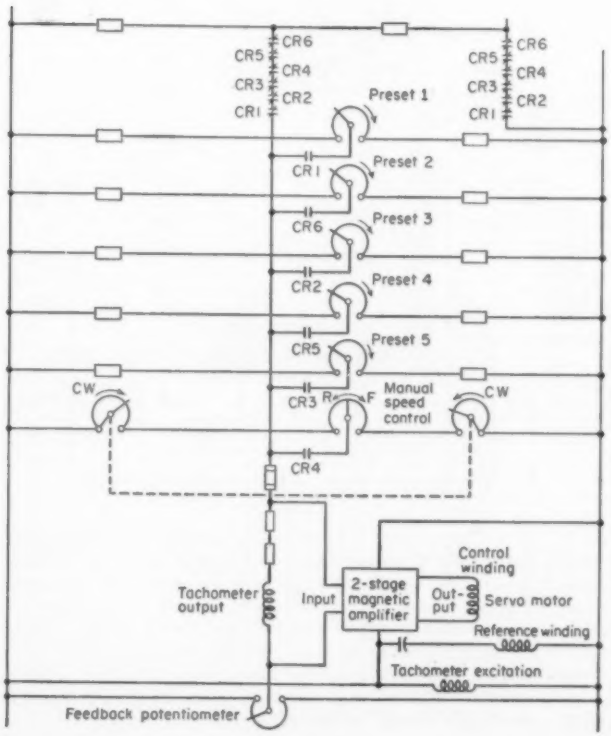
IN NEW PRODUCTS



CONTROLS FOR REMOTE, local and pre-set operations are integrated into system by standard electrical connections. Power required for control circuits is less than 100 watts. Design objectives were to replace rigid linkage with flexible electric controls, to increase operating safety by installing interlocks to protect both operator and press from out-of-sequence operation, to reduce the number of stations requiring supervision during extrusion cycle, and to reduce time of non-productive press motions by presetting critical operating sequences formerly subject to operator judgment.

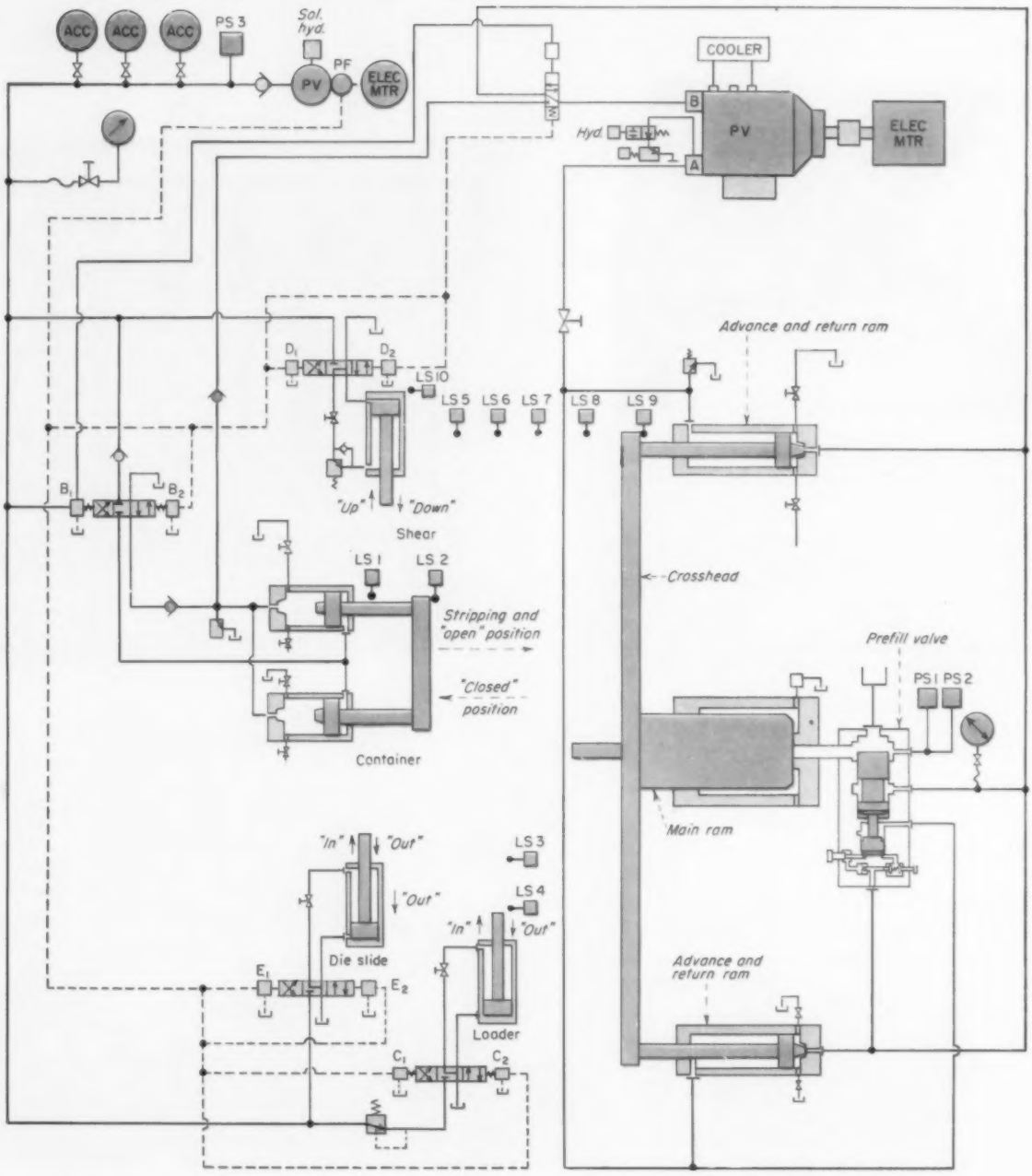


CONTROL RELAYS mounted at back of console, combined with track switches actuated by press elements, form system of interlocks and sequential control signals. Basic electrical servo units were made by Raytheon for use with Oilgear variable displacement hydraulic pumps. Relays for interlocks and programming of solenoid operated hydraulic valves were supplied by Cutler Hammer, who also fabricated the control panel.



ACROSS-THE-LINE DIAGRAM of preset unit and electrical servo system. Track switches and relays sequentially place each control potentiometer in input circuit of 2-stage magnetic amplifier. Current flow from voltage unbalance is amplified and drives servo-motor to position feedback potentiometer so current in input circuit is reduced to zero. Tachometer driven by servomotor produces velocity-feedback damping voltage in input circuit which stabilizes system. Motor also operates pilot valve of 2-stage hydraulic amplifier which positions slide block of 200-hp variable-displacement pump. System gives linear relationship between control setting and pump output.

(continued on next page)

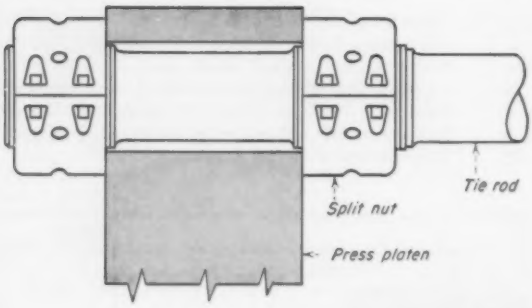


MAIN PUMP is 200-hp Oilgear two-way variable-displacement type which gives stepless variation of fluid volume delivered in either direction from 0 to 108 gpm at 3000 psi. This pump actuates main and pullback cylinders, and the container shifting cylinders when "stripping", but not when "sealing." Auxiliary pump is 20 hp variable-displacement unit with 3 accumulators which actuates shear, die slide, and container shifting cylinder when sealing. Servo control system operates main pump only. To reduce line surges, interlocks prevent starting 20 hp motor until 200 hp unit is running. An electrical time delay allows main motor to reach full speed before small motor can be started. Small pump provides pilot pressure for shifting valves so press will not operate until both motors are running. This prevents starting main pump motor under load. Interlocks also prevent: 1, damage to loader by ram; 2, starting ram unless billet charger is in; 3, moving shear down when container is closed; 4, closing container while shear is operating. Main pump is short-stroked for "break through" so less oil is bypassed to tank.

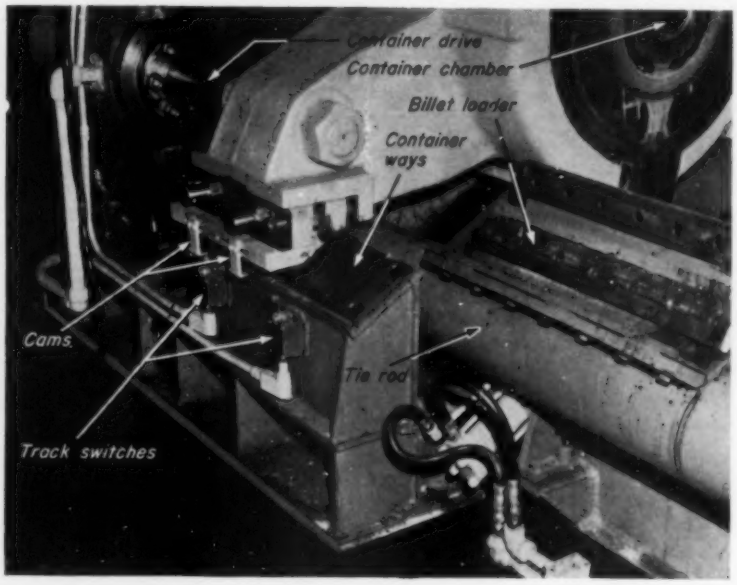
SEQUENCE CHART for automatic or manual operation of hydraulic system. In "start" position, ram is pulled back, die is in position, shear is up, and container is in "out" position. Closing container causes loader to move "in" with billet. Automatic cycle is broken here so operator can determine that billet and dummy block are on loader before ram is moved forward. Pushing "Ram-Start" button advances the ram toward billet and dummy block which are held concentric with the container. Ram stops if loader does not move out in sequence, and slows down as dummy block enters the container. After the billet is extruded, main cylinder is decompressed, ram is reversed, container is stripped, and billet-end is sheared from the die.

CYCLE	AUTOMATIC														MANUAL
SITUATION	FUNCTION	PRESET CONTROL POTENTIOMETERS					MANUAL SPEED CONTROL	SOLENOIDS							
		1	2	3	4	5		A	B_1	B_2	C_1	C_2	D_1	D_2	
Start	Press idle	—	—	—	—	—	—	—	—	—	—	—	—	—	
Container switch "closed"	Container closed on die	—	—	—	—	—	—	—	—	+	—	—	—	—	Container switch "closed"
LS 1 tripped	Loader "in"	—	—	—	—	—	—	—	—	+	+	—	—	—	Loader switch "in"; LS 1 must be tripped
LS 3 tripped	"Ram-start" interlock closed	—	—	—	—	—	—	—	—	+	+	—	—	—	"Ram-start" interlock closed
Depress "ram-start" button	Ram rapid approach	+	—	—	—	—	—	+	—	+	+	—	—	—	Depress "ram-start" button
LS 8 tripped	Loader "out"; LS 4 tripped	+	—	—	—	—	—	+	—	+	—	+	—	—	LS 8 tripped; loader moves out and trips LS 4
LS 7 tripped	Ram stops if LS 4 not tripped	—	—	—	—	—	—	—	—	+	—	+	—	—	Ram stops if LS 4 not tripped
		+	—	—	—	—	—	+	—	+	—	—	—	—	
LS 6 tripped	Slow down; dummy enters container	—	+	—	—	—	—	+	—	+	—	—	—	—	
Ride off LS 6	Rapid approach until surge valve closes	+	—	—	—	—	—	+	—	+	—	—	—	—	
PS 1 tripped at 500 psi	Manual control effective	—	—	—	—	—	+	+	—	+	—	—	—	—	
PS 2 tripped; pressure over 2750 psi	Slow-down for break through	—	—	+	—	—	—	+	—	+	—	—	—	—	
Pressure stays under 2750 psi	Forward at manual speed	—	—	—	—	—	+	+	—	+	—	—	—	—	
LS 5 tripped	Ram stops; pump shifts to full A side	—	—	—	+	—	—	+	—	+	—	—	—	—	Operator reverses ram to decompress
PS 1 tripped at 350 psi	Container stripped	+	—	—	—	—	—	+	+	—	—	—	—	—	Container switch "open"
LS 2 tripped	Close shear interlock; ram returns	—	—	—	+	—	—	+	—	—	—	—	—	—	Return ram manually
Shear switch "down"	Ride off LS 10; open interlock to solenoid B2	—	—	—	+	—	—	+	—	—	—	—	+	—	Shear switch "down"
Shear switch "up"	LS 10 tripped; close interlock to solenoid B2	—	—	—	+	—	—	+	—	—	—	—	—	+	Shear switch "up"
LS 9 tripped	Press idle	—	—	—	—	—	—	—	—	—	—	—	—	—	

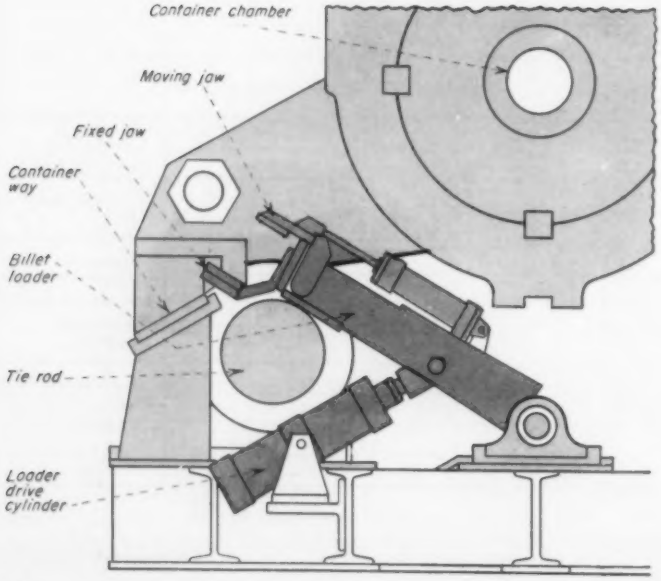
(continued on next page)



FORGED STEEL TIE RODS are fastened to press platen by split nuts using modified buttress thread with large root radius to reduce stress concentration. Placing nuts on both sides of the platen allows tie rods to be prestressed by running press at maximum hydraulic pressure of 3000 psi. When extruding, sections of tie rods between platen and cylinder absorb ram reaction force; shorter, prestressed sections between nuts do not stretch, and prevent play which would cause unequal loading of tie rods. Fatigue loads on the threads, and platen motion relative to cylinder are reduced.



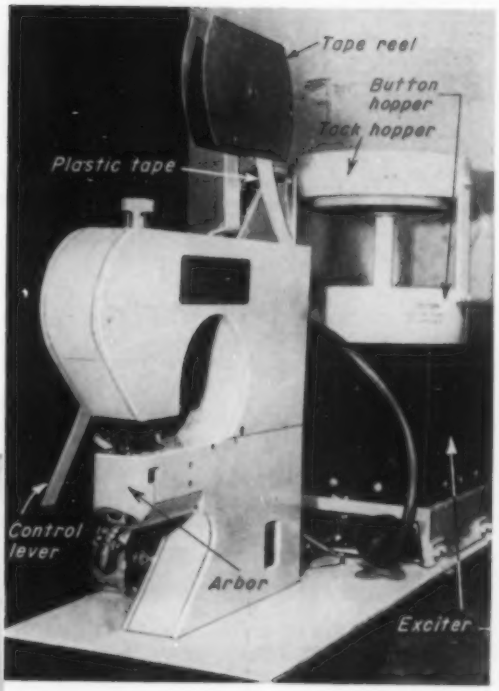
WAYS WHICH SUPPORT CONTAINER are in oblique planes with angle vertex at ram centerline. Heating container to hold billet at optimum extrusion temperature makes container expand relative to press frame, but radial way construction allows expansion while holding container chamber concentric with ram. Note dogs and track switches which interlock container position with automatic press cycle, and flexible lines to hydraulic cylinder that operates billet holder.

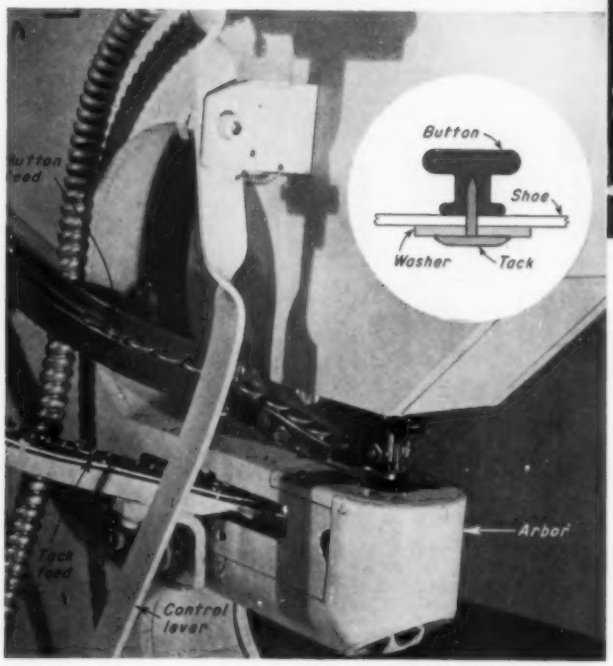


BILLET LOADER simplifies material handling by receiving dummy block and billet over lower tie rod. Pneumatically operated upper jaw clamps dummy block and holds it in position until pushed into container by ram. Then jaw is retracted and passed under ram stem, loader moves to initial position, and ram goes forward to extrude billet. Press is designed to produce 1250 to 1500 ton extruding force for high speed extrusion of 5½ by 24 in. billets at rates exceeding 40 per hr. Billet loader design is directed toward integrating press operation with mechanized billet handling systems.

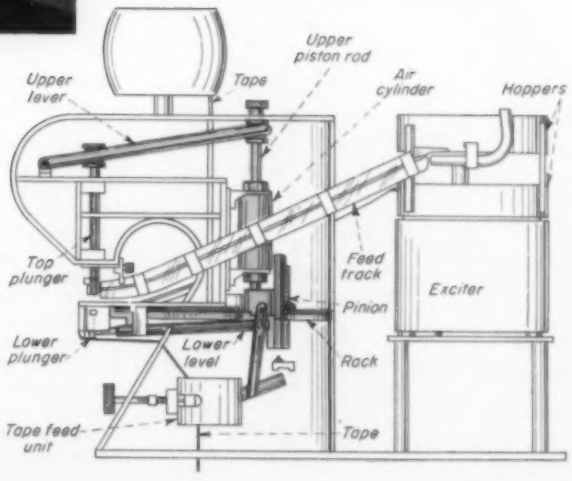
Squeeze Riveter Assembles 3 Parts

Two parts are hopper fed and a third die cut from a plastic strip in this compact assembly machine which squeeze rivets buttons on overshoes. The machine was developed at Aidlings Inc., Brooklyn, New York under the direction of Samuel Aidlin.



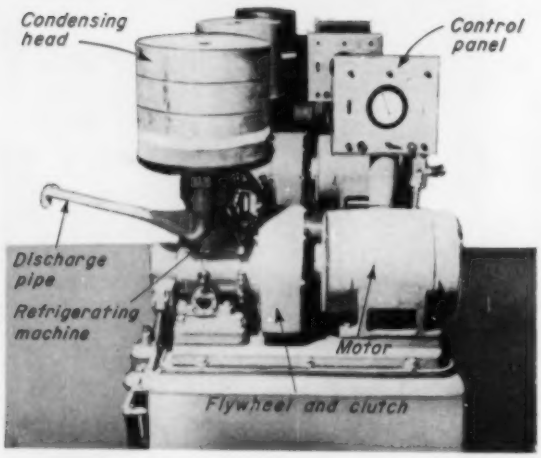


ASSEMBLY CONSISTS OF plastic button fed to plunger above arbor and a tack and back up washer which are assembled within the arbor. Mechanism to feed tacks and plastic strip from which washer is die cut had to be small so arbor would fit inside child's overshoe. Note use of two hopper feeders driven by a single exciter; feed tracks have gates with ¼-turn locks for easy clearing in event of a jam. Operator places shoe over arbor and pushes lever with hand to assemble parts on shoe.



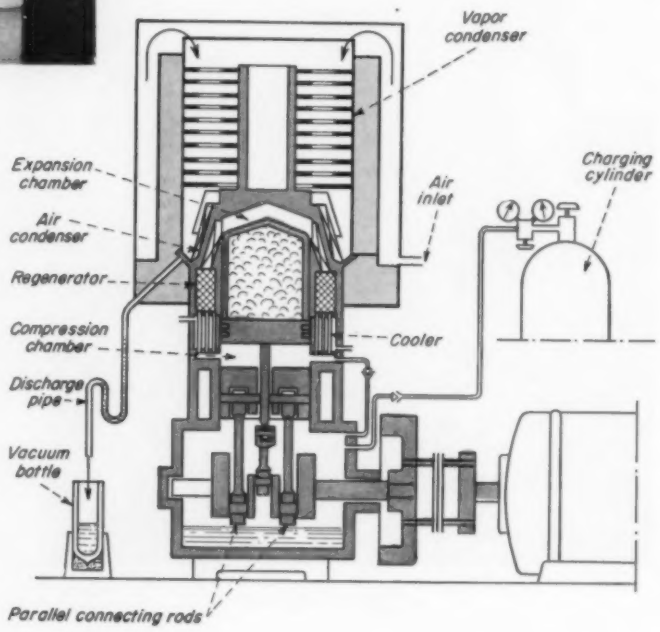
DOUBLE-ENDED, double-acting air cylinder drives mechanisms that position and assemble parts. Using pneumatic instead of electric motor drive makes machine compact for table top use by doing away with motor, clutch, flywheel and reversing starter, and also allows parts to be squeezed together at a controlled rate instead of driven together by impact. Upper piston rod pulls top plunger down to hold button against upper surface of shoe. Lower piston rod drives 3 motions: it forces lower plunger upward to drive tack, die cut washer, and squeeze these parts upward into the button; rotates a pinion to drive a horizontal rack which feeds tacks to lower plunger; and operates an intermittent pawl feed which pulls the plastic strip, from which washer is cut, through the machine.

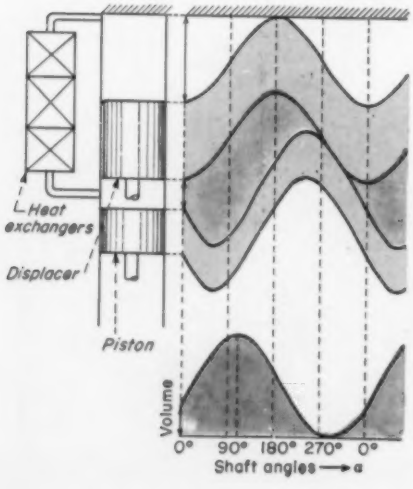
Gas Cycle Refrigerating Machine Makes Liquid Air



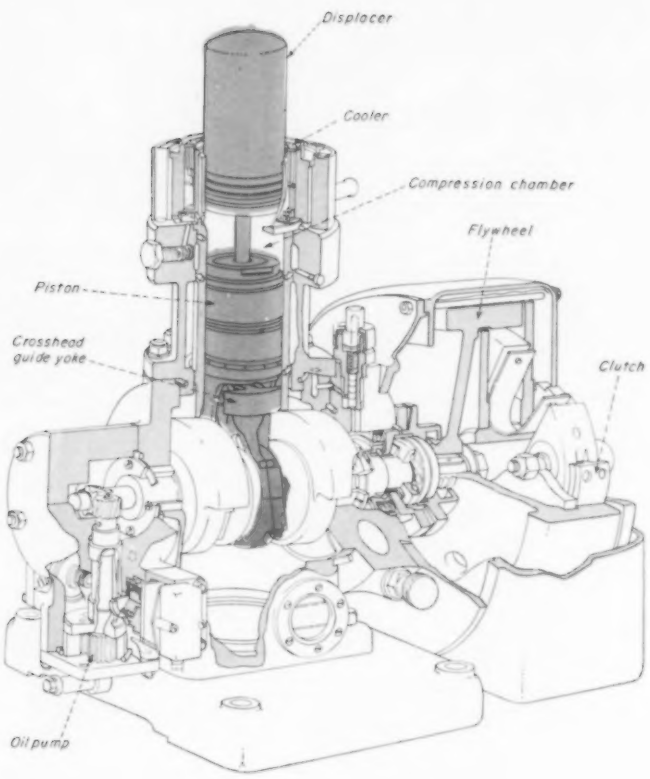
Helium is pumped periodically between compression and expansion chambers of this refrigerating machine to produce temperatures that liquify air. Developed by Philips Corp., Eindhoven, Holland, the machine uses two pistons operating out of phase in the same cylinder to make a closed-circuit gas-refrigeration cycle. Air liquifies on outer surface of cylinder head and does not contact moving parts.

SIMPLIFIED CROSS-SECTION of gas liquifying machine. Parallel connecting rods drive main piston while connecting rod to displacer drives crosshead which passes through center of piston. Crank angles provide a phase shift between harmonic motion of piston and displacer which varies volumes of the chambers periodically. Compressed gas gives up heat in lower chamber; it expands and picks up heat in upper chamber, cooling condenser surfaces. Air enters bottom of header, rises, and then passes down through center baffles where water vapor and carbon dioxide condense. Air in contact with condenser becomes liquid and is drained off to vacuum bottle. Unit averages 5 qts per hr after 15 min operation.

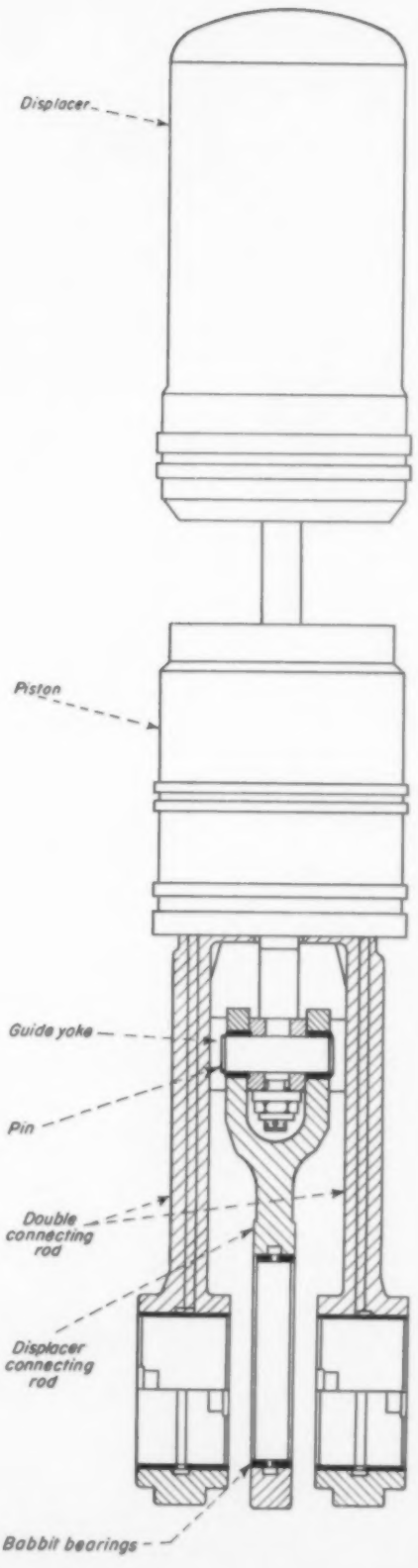




CHANGE IN VOLUME of compression and expansion chambers with shaft angle. Constant volumes of displacer and piston are shaded. Lower curve shows sinusoidal variation of compressor chamber volume and phase shift relative to expansion chamber volume. Crankcase is closed and contains helium under pressure which is fed through a regulating valve to compression chamber. Gas is compressed and passed upward through water-cooled heat exchanger, wire mesh regenerator and freezer to the expansion chamber. On the way up, helium gives off heat to water and regenerator. It absorbs heat from condenser and is cooled again when expanded in upper chamber. Helium is next pumped back to compression chamber; on the way down, it takes on heat from condenser and regenerator and is again cooled as it passes through water-cooled heat exchanger. Continuous cycling reduces condenser temperature below boiling point of liquid air.



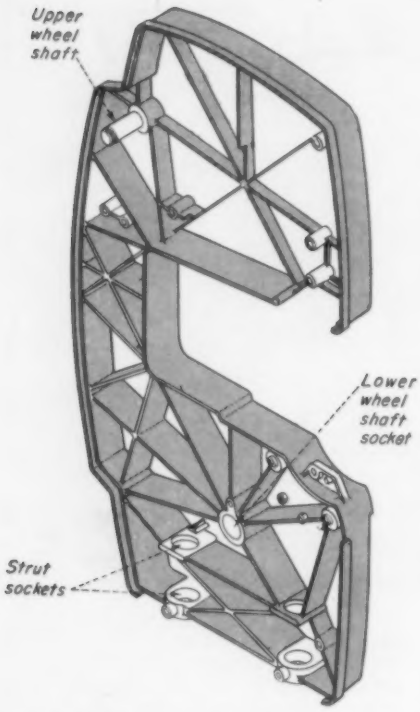
CRANKCASE IS CLOSED and contains gas used as refrigerant at pressure about equal to minimum cycle pressure in compression chamber. Regenerator and head have been removed. Filling gas is supplied only to replace occasional incidental leakage, as machine is gas tight. Pressurized operation requires heavy crankcase construction but lowers forces on drive and moving parts, and reduces friction forces as pressure differential across main piston is much lower than when crankcase is at atmospheric pressure. Gas leakage around piston is less and lost gas is automatically retained in system as the rotating shaft can be sealed more effectively than the reciprocating piston. Operating cycle at high pressure level (500 to 230 psi) makes machine compact as this critically effects volume required for given refrigerating capacity. Unit runs at 1740 rpm.



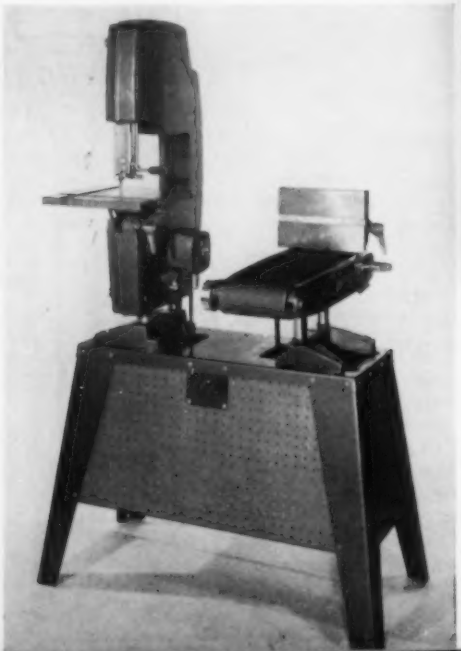
CROSS-SECTION OF RECIPROCATING ELEMENTS. Connecting rods have babbit bearings pressure lubricated by gear type oil pump through passages in crankshaft. Oil also passes up connecting rods to lubricate wrist pin and lower portion of cylinder liner in which piston travels. Lower end of cross head which drives displacer is aligned by yoke riding in cylinder liner; crosshead is also guided by sleeve in piston which is lubricated with oil from piston wrist pin. Upper washer in displacer sets expansion chamber clearance while lower washer sets clearance in compression chamber.

Die Casting Forms Saw Frame

An 11 in. bandsaw designed by Magna Power Tool Corp., Menlo Park, Cal. is housed in an aluminum die casting with a high impact polystyrene cover. Unit weighs only 32 lb. It has an automatic blade tracking mechanism and simple adjustments for blade tension and angle of saw blade and table.



FRAME CASTING is designed for high rigidity and low weight through optimum positioning of webs. Note trussed construction with deep webs which forms box structure to support mounting struts and blade wheels. Using bell crank support for upper wheel puts blade-tension load on column at rear and does not stress upper housing section. Die casting is about 32 in. high, 16 in. wide and 2 in. deep and weighs 12¼ lb.



UNIT IS DESIGNED FOR USE as a single purpose tool, in combination with other tools, or as an accessory to the Shopsmith (October 1954, page 142). It is driven with a V-belt by motor in modular stand or through a flexible coupling by Shopsmith power unit. Two tubular struts and a die-cast foot support it on both the modular stand and the multi-purpose tool. By unscrewing the three knobs, cover can be removed to change blade or adjust tension. All other adjustments are made outside of housing and from operating position.

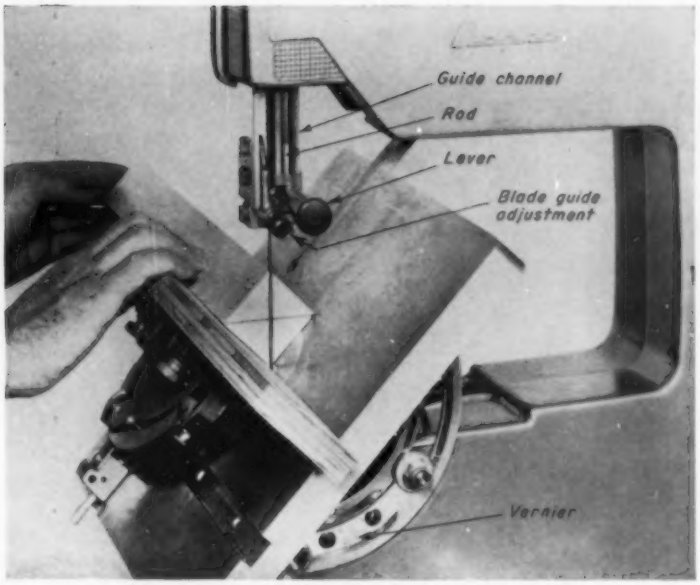
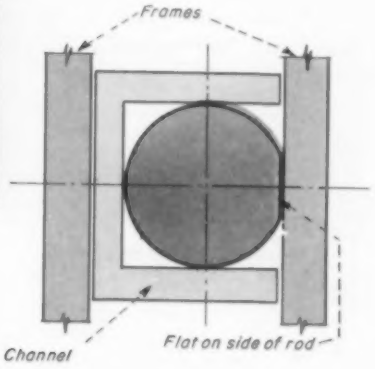
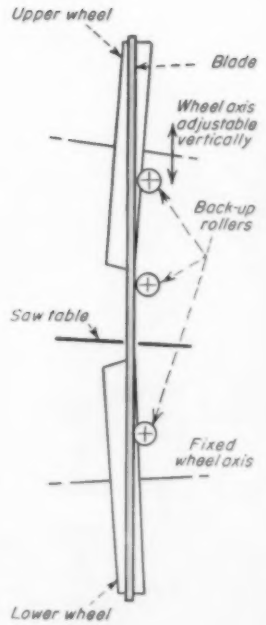
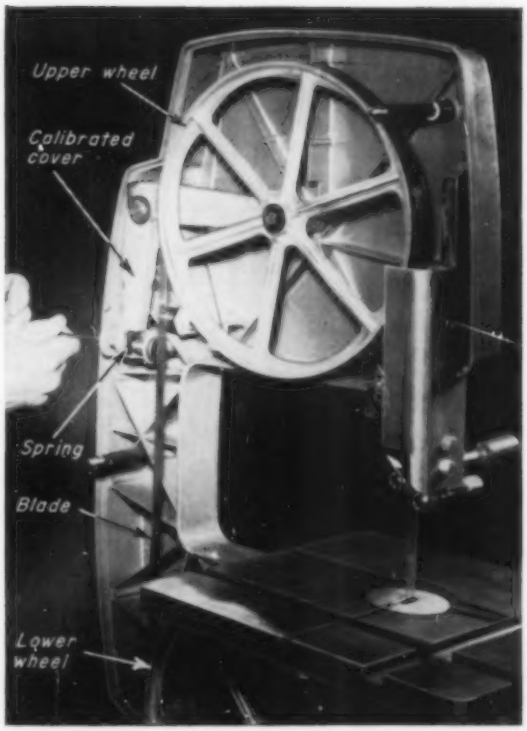


TABLE TILTS 45 deg for angle cuts and has 2 cross slots so miter gage can be used as fence for ripping (as shown) or for cross-cuts. Vernier plate on frame inside table support sectors gives 1 deg angular position accuracy. Blade guides are set for blade width with a screw adjusted with the fingers. Guide-and-guard assembly is moved or locked by lever which rotates round rod inside guide channel. Flat milled on rod allows unit to slide until rotated to locked position with handle, when round portion of rod acts as cam which jams channel against slide to lock unit at desired height.



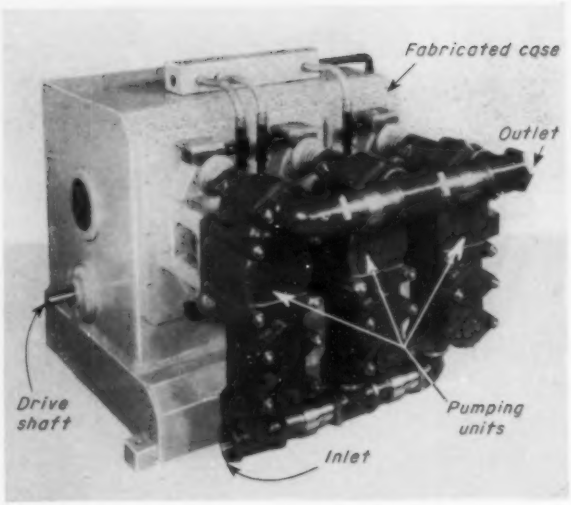


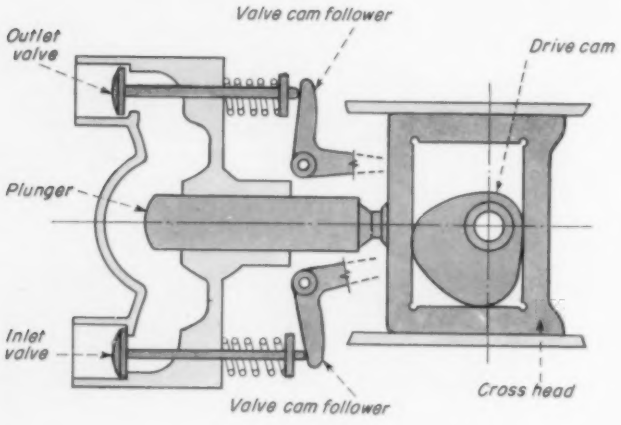
WHEELS which carry blade are sections of a cone instead of crowned cylinders and are die castings with flat surfaced solid rubber tires. Axes about which wheels rotate are tilted to give smaller cone angle between surfaces in contact with blade but still hold enough angle to cause blade to climb. This allows unit to function with blades which are not true cylindrical sections. Back-up rollers in guide assemblies above and below table and at rear of machine stop all blades at same position on the wheels. Once tension is set, all blades put on wheels automatically seek proper position and set tension. Upper wheel is supported by bell crank formed by horizontal die cast arm and vertical flat spring. Spring has slotted end which fits over adjusting screw and against nut which is positioned by adjusting screw and deflects spring against blade tension. Metal housing which fits over spring is marked with blade width at point where spring deflection curve crosses edge of housing when tension is correct.



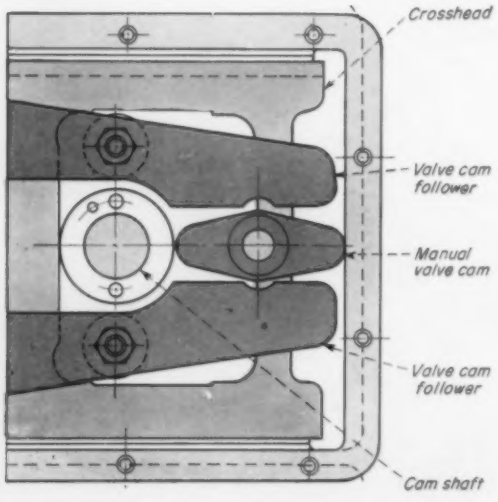
Cams Sequence Pump Motions

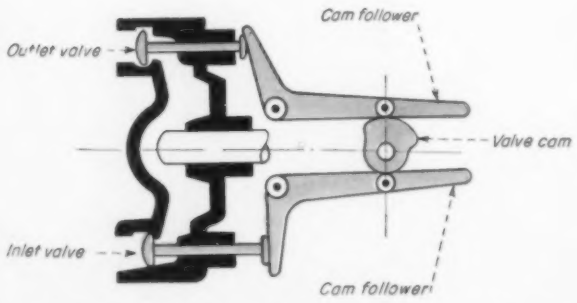
To obtain high volumetric efficiency in a pump which meters size to textile machines, Shirley Developments Ltd., of Manchester, England operates plunger and valves with cams that stop plunger while valves move.





UNITIZED CONSTRUCTION allows assembly of 1 to 5 units in a fabricated steel case to make pumps with various capacities. Each unit is self contained and is driven by a pinion on a common drive shaft which allows strokes to be sequenced for minimum discharge pulsation. A reciprocating plunger and mechanically sequenced inlet and outlet poppet valves are the only moving parts of the pumping units that contact the fluid. Drive gears and cams run in an oil bath and bearings are pressure lubricated. Placing outlet port at top of manifold allows fluid to expel air when unit is primed. As plunger does not move when valves operate and valves never open simultaneously, hydraulic shocks are avoided and volumetric efficiency is 100 per cent. Plunger stroke and diameter control quantity metered per cycle which is set when unit is manufactured.



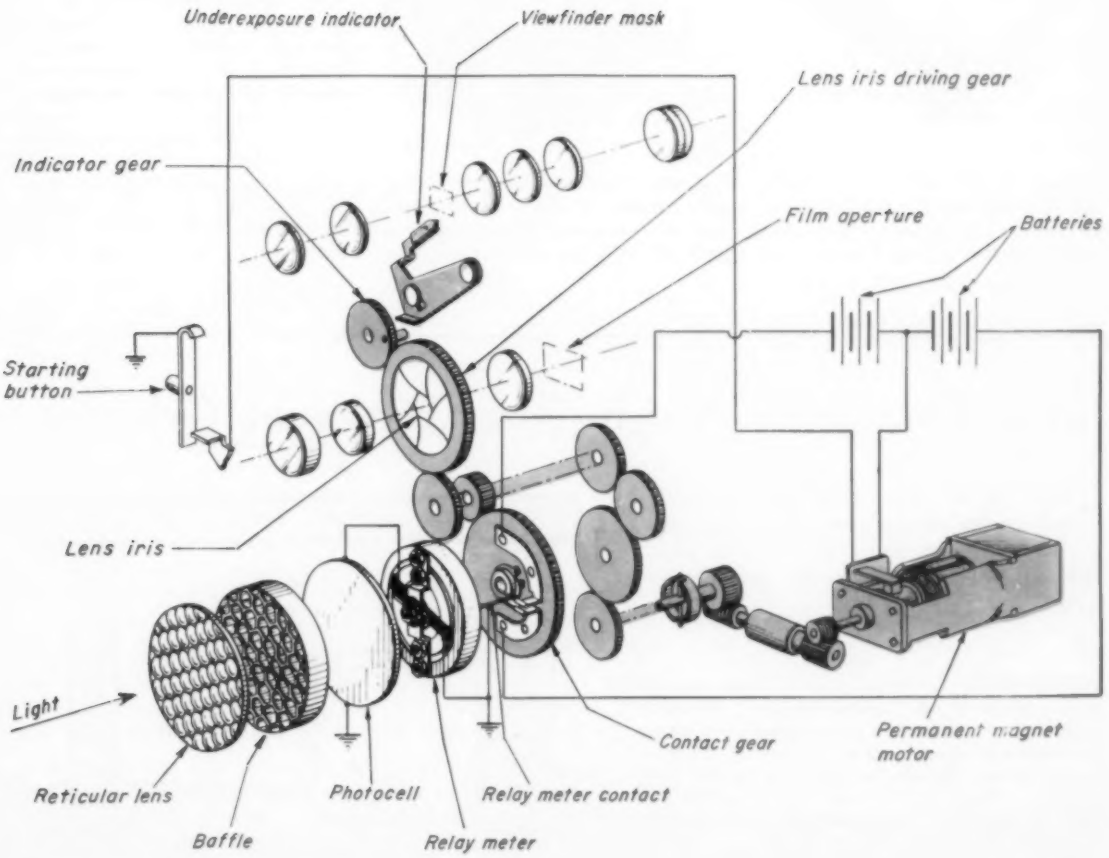


VALVES ARE OPERATED by the same cam through angle followers. Cams are mounted on shaft driven by gear which meshes with pinion on common drive shaft. Plunger cam operates crosshead which drives plunger through a ball joint to reduce effects of side thrust. Dwell in cam cycle stops plunger at each end of stroke while valves open and close. A lever operated cam is provided for manually opening both valves simultaneously to clean manifold. Pump is non-reversible.

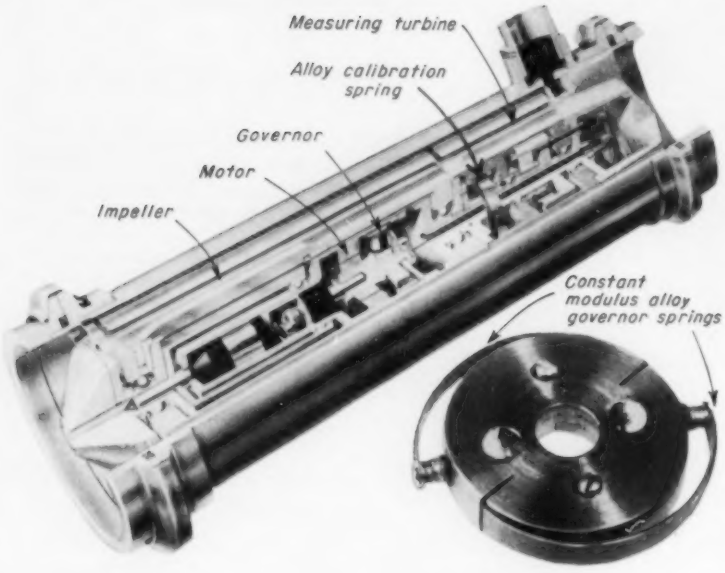
Photo-Cell Resets Camera Iris

A contact-type servo changes the iris opening of this Bell & Howell motion picture camera in proportion to light intensity to provide automatic exposure control. Light sensing elements are mounted in a control barrel which is rotated to calibrate the system for camera and emulsion speeds.

LIGHT PASSES through reticular lens and baffle to strike photo-cell, and generates current which deflects meter to a position proportional to light intensity. Contact on moving meter element, which rides between two contacts on a motor-driven insulated gear, closes proper battery circuit to drive gear in direction of meter deflection until contacts open. This sets iris opening for proper exposure. Pin on indicator gear lifts flag into viewfinder when iris approaches full open position.



Constant Modulus Springs Stabilize Mass Flowmeter

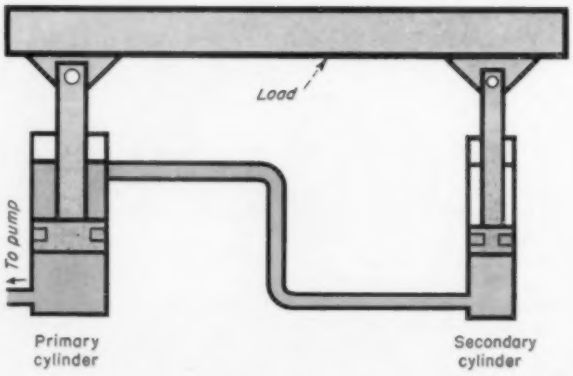


By using a constant-modulus alloy for the moving elements of a centrifugal motor governor and the calibrated spring of a torque measuring transducer, Inertial Instruments Inc., Santa Monica, Cal. has developed a mass flowmeter unaffected by temperatures from –67 to +250 deg F.

FLUID FLOWING THROUGH METER is given a known angular velocity by motor driven impeller. Torque required to decelerate fluid is measured by spring-restrained turbine which actuates transducer to convert spring deflection into electrical signal proportional to mass flow rate. Key to successful design is simple centrifugal governor that holds motor speed constant to ±¼ per cent with normal changes in line voltage and frequency, making special power supply unnecessary. Ni-Span-C elements in governor make motor speed independent of temperature over a wide range, and using this material for calibrated spring which restrains the measuring turbine reduces effect of temperature on liniarity of output signal. (Ed. Note: For information on using constant modulus alloys in product design, see July 1956, page 135.)

Series Connection Synchronizes Hydraulic Cylinders

To enable two cylinders to lift an unequally distributed load and keep motion synchronized so load will stay level, Power Jacks Ltd., London, England connects the cylinders in series.



PISTON AREA of secondary cylinder equals annular area around piston rod of primary cylinder. Oil forced from primary cylinder as it moves against load drives secondary cylinder an equal distance. Valve in piston head of primary cylinder (not shown) keeps jacks synchronized. When jacks are at bottom of cylinder, the valve is opened mechanically to pass fluid into secondary circuit.

Plane Fueling Cart Has Plastic Body

Fiberglass reinforced polyester resin forms the detachable body of this aviation fuel dispensing cart designed by engineers of the Royal Dutch Shell Group, and Thompson Bros., Bilston, England. Used with hydrant fueling stations, it carries hose, filter, meter, air separator and pressure controller.

Plastic body was used to obtain high strength, small size, low weight, and an attractive appearance.

BODY IS LAID UP BY HAND in a female mould using fiberglass mats and polyester resin, but no filler. Unit is lighter than tubular steel framed, aluminum panelled body; resists mechanical damage and does not corrode. The three-wheeled chassis has a stressed-skin frame of light-gage pressed steel—an important factor in keeping the total weight to 75 lbs.

Eight separate 70-ton rams combine to form a 560 ton unit in the Multi-Press designed by Pasadena Hydraulics, Inc. A central control panel can coordinate all rams or any two-ram group, or independent settings of pressure, temperature and operating cycle can be made at separate control stations.

Neoprene-fabric check straps installed in looms to restrict picker stick motion have lasted two to three times as long as materials previously used.

Raising headstock and tailstock increases swing above the cross-slide but keeps resultant of tool forces between ways on a universal lathe made by Maschinenfabrik Heid A. G. of Vienna, Austria. Headstock is raised with a push button controlled servo motor while tailstock is set manually with a screw.

Vertical, pulsating motion of agitator in the Frigidaire washer causes clothes to be moved only by the circulation of water in the tub.

A cold-setting photoelastic resin developed by Aero Research Limited of Canada is used to make composite models to test cemented joints.

An audible signal is produced by vibrating a wire reed on the recording arm of the portable Soundscriber when the recording head has used up space available on the record.

Steel detachable-chain with high fatigue and tensile strength for use on agricultural machinery has been developed by Chain Belt Co., Milwaukee, Wis.

Flaws in metal castings are inspected with a high intensity fluoroscope developed by U. S. Naval Ordnance Laboratory, Silver Springs, Md.

Using ductile iron in place of cast iron in paperboard press rolls enabled Black-Clawson Co., Hamilton, Ohio, to stop crowning the rolls to compensate for deflection, and cost less than steel rolls.

Mastic seals interlocked joints of an aluminum duct-board floor used in Fruehauf refrigerated trailers.

Temperature lag is reduced in the Toastmaster automatic grill by using a permanent contact thermostat.

Rubber "O" rings have replaced cast iron seal rings in the front-pump drive sleeve of the Plymouth automatic transmission.

Low-cost mechanical linkage changes the arc described by the pen of a recording galvanometer into rectilinear motion. Galvanometer is made by Texas Instruments, Inc., of Dallas, Texas.

Slotted-waveguide radiator-scanner units replace conventional reflectors in a marine radar designed by Kelvin & Hughes of England.

Aluminum skins bonded to plastic foam cores are the structural walls of a portable two-man airport control tower made by Craig Systems, Inc., Danvers, Mass.

Up to 3 hydraulic circuits can be used on the new John Deere tractor for independently controlling both integral and drawn tools.

Anti-static polystirol plastic, developed by the Montecatini Co. of Italy, rapidly disperses electro-static charges placed on its surface.

Mounting auxiliary leaves forward of the center of the main leaf increases roll stiffness of the leaf-spring suspensions used in the Australian Standard "Vanguard" car.

Concentric inlet and exhaust valves are in an Australian diesel engine.

Simple Suggestions Concerning the

Shortage of Engineers

The grave shortage of engineers can no longer be considerd acute; it has become chronic. Here are a few simple things that every company can do to contend with its own shortage of engineers.

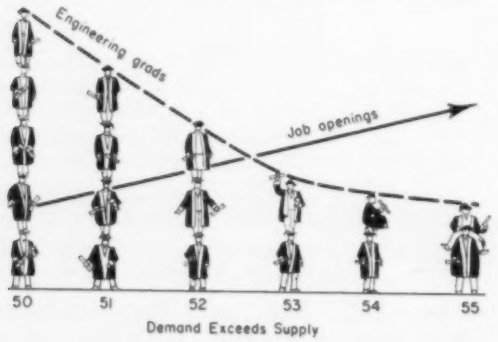
ALFRED M. COOPER, INDIO, CALIF.

SINCE 1950 there have not been enough competent engineers. Of necessity the old army personnel game of enticing good technical men away from competitors has been perfected to a fine art. This practice may alleviate the shortage in certain companies, but of course the total shortage remains the same.

In prewar years our colleges were turning out a superabundance of engineers—in 1938 some 13 times as many as there were engineers then employed in our industries. Technical men were a drug on the labor market and often were forced to take menial jobs.

But during and after World War II the need for technically trained men mushroomed. In the immediate postwar period the GI training program functioned to meet this increased demand.

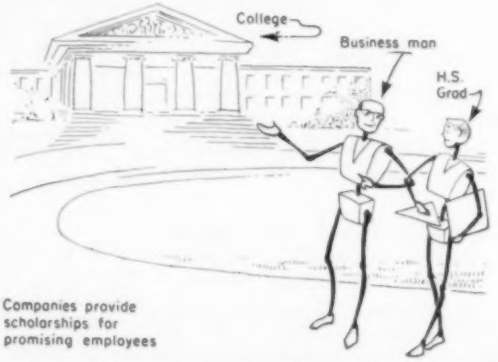
In 1950 the United States hit a peak of nearly 53,000 engineers graduated. But since then, year after year, the annual supply has sharply diminished—to 42,000 in 1951, to 30,000 in 1952, on down to 22,500 in 1955. This, through years when overall employment has steadily increased and the need for designers has risen at an even faster rate, leaves our industries suffering a critical shortage of 20,000 engineers.



Any lasting cure for shortages of engineers must of course take the form of better teamwork between those authorities in our high schools and colleges who are responsible for vocational guidance, and those experts in industry and government whose business it is to prognosticate the rate of growth within our industries.

Traditionally, the largest employers have each year taken the cream of the graduating crop of engineers; yet even the largest companies now experience difficulty in satisfying their requirements for replacements of engineers and expansion in this field. Ingenious methods have been adopted to compensate for shortages of engineers. Certain of these devices can be utilized in either large or small plants; some of them, because of the cost involved, are applicable only to larger plants.

Many plants, large and small, find it practicable to encourage high school graduates among their employees to continue their education through university extension courses. All or a large portion of the tuition costs are defrayed by the company, and scholarships are awarded employees who have been selected as demonstrating unusual potential leadership ability. Such men, after graduation, are given special consideration for promotion to executive rank.

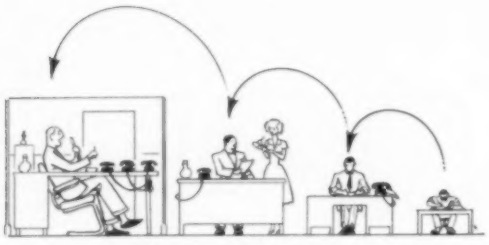


Companies provide scholarships for promising employees

Again, where there are universities nearby, plants are hiring engineering students from these schools as part time employees, and an effort is made to choose those who will qualify as permanent members of the engineering staff after graduation. Engineers hired in this manner are thus al-

ready grounded in company policies and routines. Also, in smaller plants this procedure makes it easier to secure the services of a better grade of engineers.

Personnel officers contend that where it is possible to select and upgrade employees within the ranks it becomes practicable to secure not only proficient engineers who



Promotion From Within

know their way around the particular plant, but also better material for promotion to higher executive positions.

Obviously, either the upgrading of shop employees or the hiring of part time student engineers, may be preferable as a method of selection to employing "bottom-of-the barrel" among the annual crop of engineering graduates, which are usually the only ones available to the smaller plant when there is a shortage of technical help.

Existing engineering shortages have been alleviated in larger plants by selecting nonengineering graduates from among the shop and office employees–preferably those who have majored either in mathematics or physics–and training these as engineers. It has been found that intensive five month courses can convert such men into well qualified engineering assistants. Here again, it is possible to more carefully screen these men for their leadership qualities.

Larger plants have the advantage of being better able to absorb the cost of an elaborate, formal training program. But when the training can be given it has been found practicable to assign two or three such nonengineering graduates as assistants to engineers, thus relieving the engineers of much detail work and freeing their time for broader, more vital phases of design activity.

Another factor that is helping to solve the shortage problem is that personnel executives are beginning to look with definite disfavor on the practice of employing engineering graduates as draftsmen. This time honored method of inducting engineers into industry is now considered wasteful of skills that are in too short supply. It has been found that high school graduates can be readily developed into competent draftsmen, and this again frees the engineer to concentrate his efforts on legitimate engineering work. It has also been found that too many years of routine grind at a drafting table may hamper the engineer for imaginative design effort.

Then, too, it has been ascertained that the time of too many engineers is taken up with detail work of a purely clerical nature which in itself does not call for engineering skill. This may include operation of a computing machine, and it has been discovered that no sacrifice in efficiency results when experienced women computing machine operators are substituted for engineers who have been handling this nontechnical work.

In connection with studies of this general shortage problem it frequently develops that job specifications are found to call for engineering degrees when the work in many instances could as well be handled by people of lesser attainments. This is a carryover from the days of surplusages of technical help, when it would often be said, "It would be nice if we could have engineers on this job."

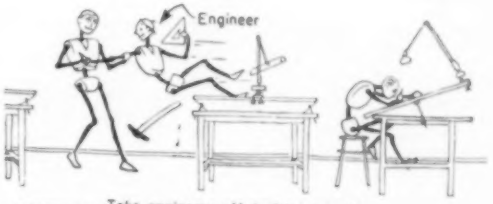
Most experts caution that efforts to induct too many nonengineering employees into a design organization may have a deleterious effect on the quality of imaginative design. In the long run, the answer to engineering shortages must take the form of guidance of more students into this field. In the meantime the shortage problems must be met and overcome.

Undoubtedly, the impression prevailed for some time among vocational counselors that the GI training program might well flood the labor market with engineers, and college freshmen and high school students were cautioned about preparing for an overcrowded profession. The steady increase in overall employment, continuing year after year, has been something of a surprise to close observers everywhere.

It is also true that there has occurred a shift in emphasis in high school curriculum building which must, if continued, affect adversely the number and quality of entrants into our engineering schools. As one instance of this, nearly 1500 of our high schools last year dropped courses in mathematics and science–courses of study which are fundamental in preparation for entrance into any engineering college. It would be interesting to know what courses of study were substituted for these.

In time, of course, our educational plant will catch up on shortages of engineers, due to whatever cause. In the interim, one or more of the remedies which have been suggested, which have been found effective in a number of plants, may help in spreading too few engineers over a plethora of jobs.

In some cases, too, it will be found that the emergency measures that have been put into effect (such as substitution of women computing machine operators for engineers,



——— Take engineers off drafting boards

and the employment of nonengineers as draftsmen) may be considered so effective and economical that engineering skill will no longer be dissipated on less demanding jobs. Likewise, any system that is developed for upgrading employees already on the payroll may be well worth continuing in effect. Particularly is this true when such a program has for one of its objectives developing future executives. Industry has never had quite enough material from which to fashion topflight executives.

In any event, if the existing shortage of engineers results in the development of superior methods of allocating trained manpower to jobs calling for such training, the emergency may have been well worthwhile.

Table I—Composition of High Temperature Alloys Listed in Tables II-IV

Alloy	Constituent, per cent									
	Fe	Ni	Co	Cr	Mo	W	Ti	Al	C	Cb
AISI 1015	Bal.	....	....	....	....	....	....	....	0.15	....
AISI 1030	Bal.	....	....	....	....	....	....	....	0.30	....
AISI 410	Bal.	....	....	12.0	....	....	....	....	0.10	....
1 Cr–0.5 Mo	97.0	....	....	1.0	0.5	....	....	....	0.10	....
AISI 321	69.5	10.0	....	17.5	....	....	0.5	....	0.06	....
AISI 304	69.0	10.0	....	19.0	....	....	....	....	0.08	....
16–25–6	50.5	25.0	....	16.0	6.3	....	....	....	0.09	....
N–155	30.0	20.0	20.0	21.0	3.0	2.2	....	....	0.13	1.0
Nimonic 80A	0.5	76.0	....	20.0	....	....	2.5	1.1	0.05	....
Inconel X	7.0	72.5	....	15.0	....	....	2.5	0.7	0.05	1.0
M-252	2.0	53.5	10.0	19.0	10.0	....	2.5	0.75	0.10	....
X-40	1.0	10.3	55.0	25.0	....	7.4	....	....	0.48	....
J-1570	2.0	28.0	37.5	20.0	....	7.0	4.2	....	0.20	....

Metals at Elevated

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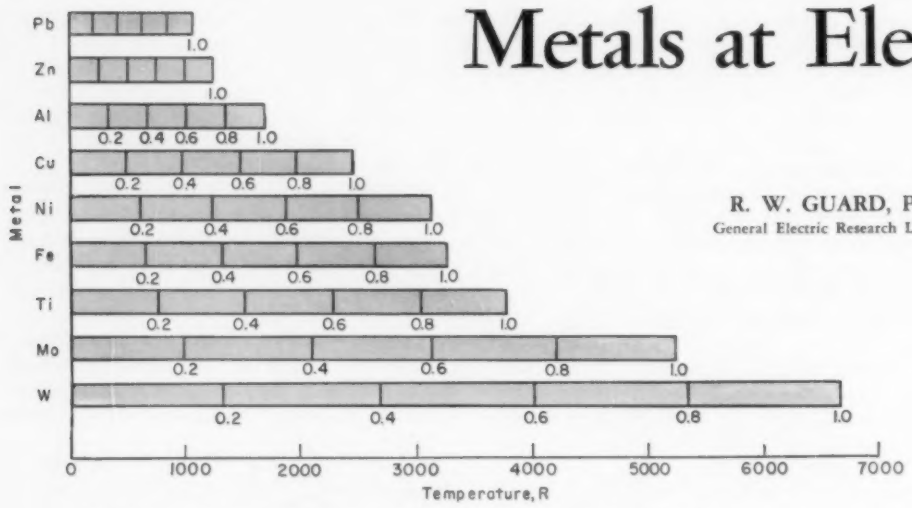


Fig. 1—Homologous temperature scale for several common metals. Limits of the scale are absolute zero (0) and the melting point of the metal (1.0).

Hot and cold behavior of metals compared using homologous temperature scale; fatigue vs rupture stress as design criterion, predicting long-term properties from short-term tests

THE WORDS **elevated temperatures** mean different things to different metals; for example, room temperature is **hot** to gallium (melting point 85.6 F), **warm** to lead (melting point 621.3 F) and **cold** to iron (melting point 2802 F). A new scale, the "homologous" temperature scale, defines the elevated temperature region more precisely. This scale, shown in Fig. 1, uses absolute zero as 0 and the melting temperature as 1.00 for each metal. The intervals are divided into equal parts.

Metals show generally similar behavior at similar homologous temperatures even though their melting points are very different. When cold-rolled nickel and cold-rolled copper are annealed at various temperatures, as shown in Fig. 2, softening takes place at an homologous temperature of about 0.35 in both materials. While the behavior of alloys is complex, alloying generally shifts the curves to higher homologous temperatures. The band given for each material shows the general variation in commercial alloys.

Table II—1000-Hr Rupture Strengths for High Temperature Alloys

Alloy	Rupture strength at various temperatures, psi × 1000				
	900 F	1200 F	1350 F	1500 F	1700 F
AISI 1015	19.0	2.6	1.0	....	....
1 Cr–0.5 Mo	28.0	6.0	....	....	....
AISI 304	49.0	14.4	7.5	3.7	....
AISI 321	....	17.4	7.7	3.3	....
16–25–6	....	37.0	18.5	8.0	....
N–155	....	38.0	22.8	12.6	....
X–40	....	48.5	34.5	21.4	14.1
Nimonic 80A	....	55.2	29.0	13.0	....
Inconel X	....	62.5	37.5	16.5	6.8
J–1570	....	84.0	50.0	24.0	13.5

Temperatures

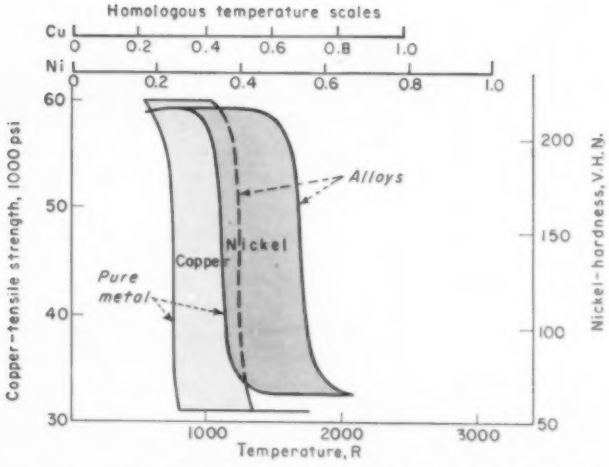


Fig. 2—Cold-worked metals can be softened by annealing at about 0.35 on homologous temperature scale. Alloying raises the annealing temperature above that for pure metals. Scale at top indicates homologous temperatures for the two metals.

Elevated temperatures, then, refer to temperatures above 0.35 on the homologous scale for most alloys. Chemical compositions of typical high temperature alloys are given in Table I.

With the region of interest defined, **hot** and **cold** behavior may be compared. The effect of loading time is the first and most important difference. At homologous temperatures below 0.30 to 0.40 a metal loaded below the yield stress deforms elastically and no further deformation occurs regardless of load duration. For this reason, the yield stress is a satisfactory design criterion at cold temperatures on the homologous scale.

Above 0.35 on the homologous scale, time becomes important for three reasons: (1) The material deforms with time when loaded below the short-time yield stress. This time-dependent deformation is referred to as creep. Appreciable creep can take place at stresses far below the short-time yield strength. (2) Material properties may vary because of microstructure changes in the metal such as aging, recrystallization or annealing of cold-worked material. These changes can occur very slowly, over periods as high as 10,000 hr, and may lead to deleterious loss in strength or to embrittlement. (3) The material surface may be attacked by the environment. This temperature effect will not be covered here.

Mechanical Properties

Creep strength and rupture strength are the most important mechanical properties at high temperatures. The creep strength is the stress which causes a certain specified deformation in a fixed time. The rupture strength is the stress which causes rupture in a specified time. The creep strength is better for design when the allowable deformation is small; when failure can occur only by breaking, the rupture strength should be used.

Since these mechanical properties are not necessarily proportional to tensile strength, they must be determined experimentally. Rupture strength values for some typical high-temperature materials are compared in Table II, 1000-Hr Rupture Strengths for High Temperature Alloys.

Rupture data for different stresses can be summarized using the Larson-Miller parameter. Raising the test temperature causes a certain reduction in rupture time. By combining time and temperature into a single equation of the form shown in Fig. 3, it is possible to compare tests at a number of different temperatures. This data can also be used to predict stresses for long-time service from short-time tests at higher temperatures. The accuracy of such predictions is about 10 per cent in stress.

EXAMPLE: The blades in a gas turbine for power generation are to be made of J-1570 alloy. Desired service life is 10,000 hr at 1450 F. The stress-rupture curve for J-1570 in Fig. 3 is based on tests up to 1000 hr and 1800 F. For 10,000 hrs. and 1450 F, the Larson-Miller parameter P is 45.2×10^3. From Fig. 3 the rupture strength for these conditions is 24,000 psi.

When materials were first used at high temperatures, most failures were due to excessive creep or rupture. More

Table III—Fatigue Strengths for High Temperature Alloys

Alloy	Stress for Failure in 10^8 Cycles, psi × 1000		
	1200 F	1350 F	1500 F
16-25-6	41	30	19
X-40	47	37	29
Nimonic 80A	50	40	31
N-155	61	50	34
J-1570	63	62	47
M-252	70	61	45
Inconel X	47	44	38

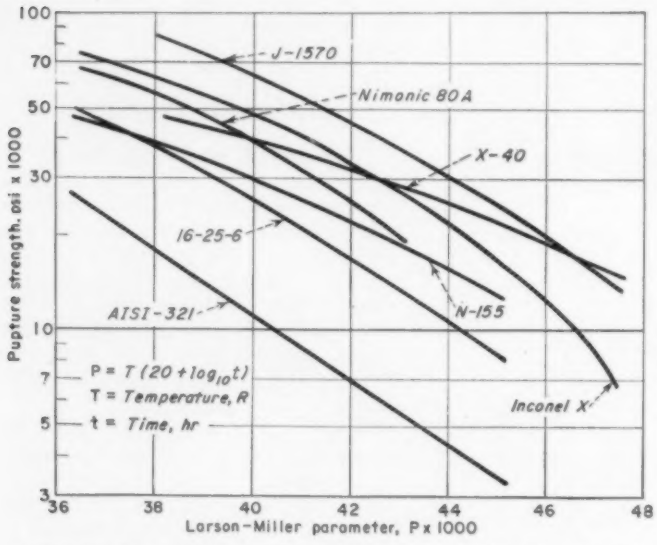


Fig. 3—The Larson-Miller parameter trades temperature for time in comparing creep and rupture tests under different conditions.

recently, alternating stresses and temperatures have increased to the point where fatigue life becomes important. Table III gives elevated temperature fatigue properties of some high-temperature alloys. Fatigue properties are damaged by having very large grain size (ASTM 2 or larger) so that processing must be controlled. This growth can occur during hot working of the final part.

The relation between fatigue failure and stress-rupture failure is illustrated by Fig. 4. While rupture and creep stress are still the limiting strength at high temperatures, at lower temperatures the fatigue strength may be less than the rupture strength for equivalent service times. This is because in alloying, the fatigue strength has increased much less than the rupture strength. In those cases where 10^8 cycles occur in less than 1000 hr, the fatigue problem becomes even more important because the fatigue strength is lower than the rupture strength over a wider temperature range. For example, many fatigue failures occur in turbine bucket dovetail joints which operate at 1200-1350 F.

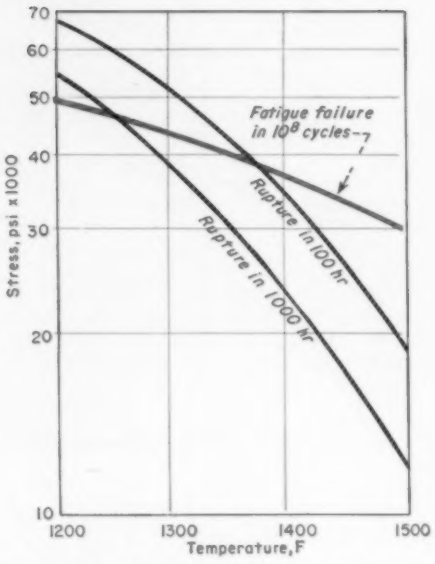
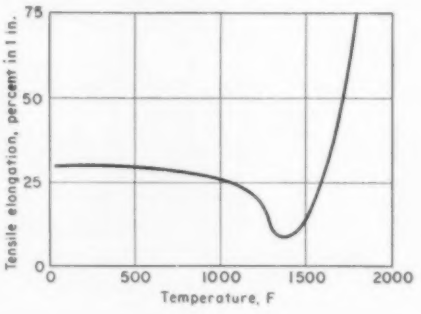


Fig. 4—Relation between fatigue and rupture strengths for Nimonic 80A blading alloy. In normal gas turbine service, 10^8 cycles will occur in about 1000 hr. As time to reach 10^8 cycles decreases, fatigue failure predominates at the lower temperatures.

Fig. 5—Many high temperature alloys show a definite drop in ductility at some intermediate temperature. Data shown is for J-1570, a precipitation hardening nickel-cobalt-chromium alloy.



While some metals become more ductile as temperature increases, precipitation of carbides and intermetallic compounds in other alloys causes a ductility loss in certain temperature ranges. The embrittlement is accompanied by the incidence of intergranular cracking and a marked increase in notch sensitivity. The behavior of J-1570, an alloy which shows some susceptibility to embrittlement, is shown in Fig. 5. While loss in ductility varies considerably between alloys, those which derive their strength from precipitation, such as J-1570, M-252 and N-155, are more susceptible.

In addition to mechanical fatigue, failure can result from alternating thermal stresses. Thermal fatigue is com-

plex and much research remains before it can be completely understood. Large thermal stresses can be avoided by minimizing temperature gradients and matching the expansion characteristics of adjoining sections.

Physical Properties

Some properties of metals are temperature dependent, but not necessarily time dependent. Thermal conductivity, thermal expansion and dynamic elastic modulus are examples of such properties. In the absence of serious microstructural changes, these properties are not dependent on the length of test.

Conductivity and expansion coefficient are rarely influential in ordinary mechanical tests. But they are important in determining thermal stresses originating from non-uniform or fluctuating temperatures. For example, when heating or cooling a metal protected with a ceramic coating, a sharp temperature gradient exists across the low-conductivity ceramic. This difference in temperature, when coupled with a difference in expansion coefficient, can lead to very high stresses. The expanding metal stretches the coating until rupture may occur. High thermal stresses can cause failure in all-metal structures as well. Typical expansion coefficients for some common metals, alloys and ceramics are given in Table IV.

Variation of elastic modulus with temperature is of interest. While not time dependent, measurements made at temperatures where creep occurs, will generally be low. In this region, rapid measurements are made, usually with a tuning fork. Values determined dynamically in this manner should be used only in applications where the loading time is brief. The data in Fig. 6 are given for pure metals. Values for the elastic modulus for several high-temperature materials are given in Table V. Most alloys have values similar to that of the base constituent.

Processing Methods

High temperature alloys most commonly used may be considered in two classes: those which are strengthened by heat treatment and those strengthened by cold work. The latter class are limited to the lower temperatures, as they tend to soften by recovery or recrystallization at about

Table IV—Thermal Expansion Coefficients for High Temperature Materials

	Temp. Range from 70 F to	Coeff. of Thermal Expansion per deg F $\times 10^{-6}$
METALS		
Molybdenum	3250	3.8
Tungsten	5400	3.7
Chromium	1300	5.2
AISI 410	900	6.6
Iron	1450	8.1
Nickel	1650	9.0
Inconel X	1600	9.2
X-40	1500	9.2
AISI 321	1450	10.5
AISI 304	1650	10.7
CERAMICS		
$3Al_2O_3$–$2SiO_2$	1450	3.1
WC	1450	3.5
Zirconia	1450	3.6
TiC	1450	4.2
Alumina	1450	4.5
Magnesia	1450	7.5

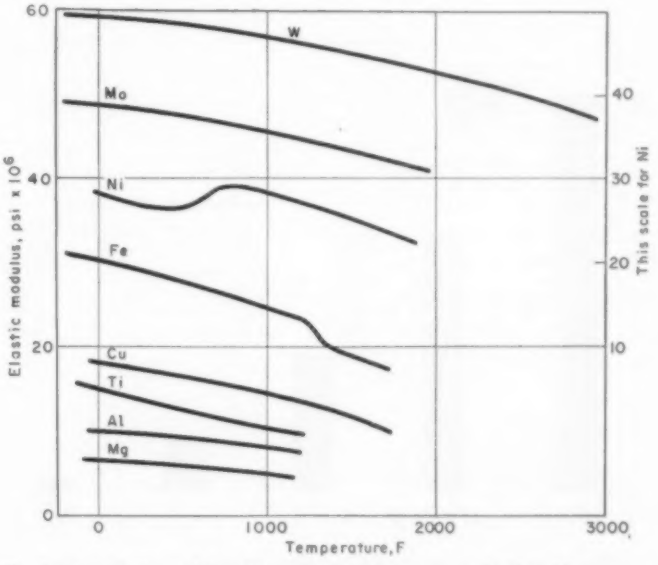


Fig. 6—The elastic modulus of pure metals decreases gradually with temperature. The anomolous behavior of nickel is related to its magnetic properties. Data determined dynamically.

Table V—Elastic Modulus for High Temperature Alloys

Alloy	Elastic Modulus, millions psi							
	Room	400 F	600 F	800 F	1000 F	1200 F	1350 F	1500 F
AISI 1030	31	29	28	27	25	23	..	..
AISI 410	32	30	29	27	25	23	20	15
AISI 321	29	27	26	24	23	21	19	18
Nimonic 80A	27	27	23	24	25	27	19	16
M-252	31	29	27	28	26	25	22	19
X-40	29	28	27	25	24	24	23	21
J-1570	33	32	31	29	28	27	26	..
Inconel X	31	30	28	29	25	23	21	19

0.4 on the homologous temperature scale. Their use is widespread in sheet form. In some cases, such as turbine rotors where temperatures are moderate, fairly massive pieces are strengthened by cold forging. The present molybdenum turbine bucket alloys derive their strength from cold deformation.

With the increased use of sheet material, good weldability has become an important property. Many of the high-temperature alloys contain reactive elements such as aluminum and titanium so that inert atmosphere protection is necessary during welding. Some compositions are susceptible to weld-cracking. There is no satisfactory way to predict whether a given composition will weld satisfactorily. Precautions against weld-cracking such as preheating, clamps, and slow cooling should be used.

Trends

The trend in elevated-temperature alloys is to higher and higher temperatures because of efficiency gain in power applications. Present materials permit steam turbine operation at 1050-1150 F and gas turbines at 1500-1600 F. If the present rate of temperature increases persists, 1966 should see steam temperatures of 1250-1300 F and gas-turbine temperatures over 2000 F. In order to meet these demands, superior materials must be developed. While existing austenitic nickel-base alloys may have enough strength for steam-turbine applications, they may not retain this strength over the long 100,000 hr service periods required. Particularly troublesome is embrittlement which occurs for many of the present austenitic steels in the temperature range 1200-1250 F.

While high-melting metals such as molybdenum, niobium and tungsten have sufficient strength for use over 2000 F, they lack oxidation resistance. Before widespread use in gas turbines, coating materials for the metals must be developed which are non-porous and sufficiently strong to resist cracking and impingement of particles in the gas stream. Satisfactory molybdenum coatings should be available in the near future.

As operating temperatures approach 3000 F, even the high-melting metals weaken, turning attention to ceramics. Fig. 7 shows the number of metal and ceramic materials having high melting points. While ceramics are weak because of their brittleness, new designs are being developed to accommodate this lack of ductility. The important requirement is to avoid sharp changes of section which act as stress raisers, and to minimize temperature gradients and sharp temperature fluctuations.

Ceramics made of silica, mullite, forsterite, alumina, spinel, zircon, beryllia, zirconia, magnesia and thoria are used as refractory materials. Other carbides, sulphides, nitrides and borides have been used experimentally or on a limited scale for jet engines and rocket engines.

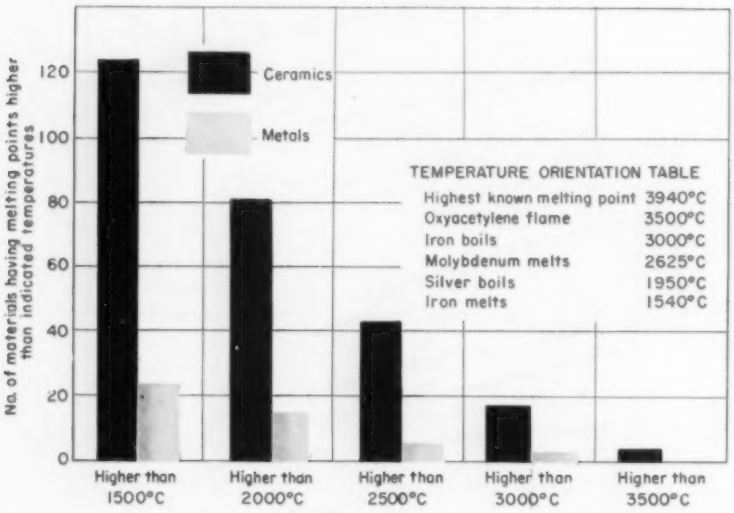


Fig. 7—As service temperatures increase, the number of useful metals drops, and ceramics then become more important as structural meterials.

EDITOR'S NOTE—Reflecting the growing significance of this problem of increasing service temperatures the following articles have appeared in recent issues:

"High Temperature Materials," September 1956 page 186; general review of early development, properties required, methods of evaluation, materials available and trends.

"Heat Resistant Cast High Alloys," February 1955 page 163; data on strength and corrosion resistance under repeated heating cycles in atmospheres above 1200 F.

"Special Coatings for Metals Used at High Temperatures," January 1954 page 135; an alternate high temperature design technique.

"High Temperature Test Data and Their Importance in Design," October 1953 page 182; molybdenum and molybdenum-base alloys as high temperature materials.

In Product addition to these feature articles, the 1956 Design Handbook Issue included the following series of articles with data on materials for elevated temperature service:

"High Temperature Properties of Nimonic 95," page B19; data from short-time tensile and 10,000 hr creep tests at temperatures up to 1800 F.

"Nickel-Aluminum Alloys for High Temperature Applications," page B20; properties at room temperature and 1500 F for a nickel alloy with 17.5 per cent aluminum.

"Cermets for Thermal Shock," page B22; properties of fine materials at 1800 F; advantages and disadvantages listed.

"Stress-Rupture and Tensile Strength of Thermenol, page B26; comparison of stress rupture life with stainless at 1200 F.

See also three articles in Section B and one article in Section C of the forthcoming Product Design Digest Issue, summarizing recent data on static and dynamic properties of materials:

"Wrought Alloys for Jet Engine Bucket Applications" page B6.

"Alloys for High Temperature Applications" page B8.

"Boron-Modified Cobalt-base S-816 Alloy" page B20.

"Industrial Applications of Ceramics" page C12.

Collapsing Pressures Of Non-Symmetrical Bodies

Equations for an approximate method for determining collapsing pressures

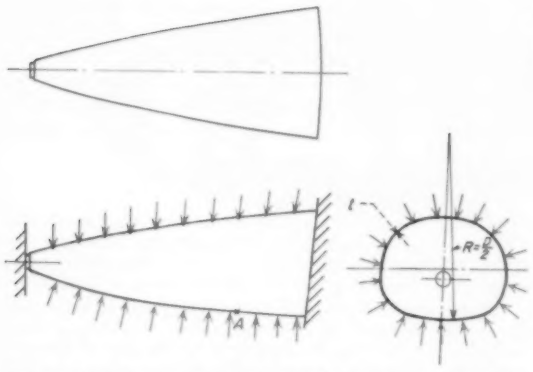


Fig. 1—Typical non-symmetrical cylindrical shape under load from uniform external pressure P_r. Point A is point of flattest section and therefore assumed to be the weakest point.

MELVIN MARK
Consulting Engineer, Cambridge, Mass.

SYMBOLS:

D —diameter of the cylinder, in.
E —Young's modulus, psi.
K —loading constant
L —length of cylinder, in.
L_c —critical length, in.
L_e —equivalent length for non-symmetrical body, in.
P —collapsing pressure for short tube, psi.
P_n —collapsing pressure for cylinder of infinite length, psi.
P_r —collapsing pressure for non-symmetrical body, psi.
t —thickness of the cylinder, in.
μ —Poisson's ratio

DETERMINATION of collapsing or buckling pressures of non-symmetrical bodies is generally difficult and complex. For an infinitely long thin cylinder, however, the collapsing pressure can be simply expressed as

$$P_n = \frac{2E}{1-\mu^2}\left(\frac{t}{D}\right)^3 \qquad (1)$$

The collapsing pressure of a tube of finite length, L, is greater than that for an infinitely long tube. A "critical length," L_c, defined as the minimum length beyond which collapsing pressure is independent of length, is given by the following equation from "On the Theory of Elastic Stability," by R. V. Southwell, *Philosophical Transactions*, Vol 213-A, page 187:

$$L_c = KD\sqrt{\frac{D}{t}} \qquad (2)$$

where K is a constant for any given set of end constraints and a given value of μ. The collapsing pressure P of short tubes or cylinders is inversely proportional to the length. Therefore,

$$P = \frac{P_n L_c}{L} \qquad (3)$$

Combining Eqs (1), (2) and (3) the expression for the collapsing pressure of a short tube becomes:

$$P = \frac{2EK t^{2.5}}{(1-\mu^2) L D^{1.5}} \qquad (4)$$

Eq (4) can be applied as an approximate method to shapes other than short tubes, such as the radome in Fig. 1. The shape is treated as a cylinder whose diameter D is equal to the twice the radius of curvature at the center of the flattest, and therefore the weakest, unsupported portion (point A in Fig. 1) and with a length L_e such that it buckles at the same pressure as the actual part. Thus, for this shape, Eq (4) becomes:

$$P_r = \frac{2EK t^{2.5}}{(1-\mu^2) D^{1.5} L_e} \qquad (5)$$

where P_r is the collapsing pressure of an "equivalent length" equal to L_e. A similar expression can be written for any other non-symmetrical shell structures.

A check on the validity of this approximate approach with respect to the quantities t and D was made using plastic models of the radome. Table I gives test results for various size models. Models *1* and *2* were identical in every respect except thickness. Model 3 was identical to models *1* and *2* with the exception that it was reduced in

Table I—Buckling Pressures Based on Test Results

Model No.	Radome Thickness in.	Radius of Curvature at Flattest Unsupported Portion of Radome, in.	Buckling Pressure psi (From test results)
1	0.065	15	3.4
2	0.051	15	1.8
3	0.039	9.5	1.96
4	0.05	9.5	3.0

Table II—Buckling Pressure Ratios

	Test Values	Calculated Values (Eq 5)
P_1/P_2 (Models 1 and 2)	1.89	1.84
P_1/P_3 (Models 1 and 3)	1.74	1.81
P_2/P_3 (Models 2 and 3)	0.92	0.99
P_1/P_4 (Models 1 and 4)	1.13	0.98
P_2/P_4 (Models 2 and 4)	0.60	0.53
P_3/P_4 (Models 3 and 4)	0.65	0.54

thickness and had a smaller radius of curvature at the center section of the flat unsupported section. Models 3 and 4 differed only in thickness. All models were of the same material (Selectron 5003 resin and No. 181 glass cloth).

Tests were made by evacuating the inside of the models and measuring deflection at a point where the deflection was the greatest (this was at the center of the flattest unsupported section). Plotting deflection versus pressure, the buckling pressures was obtained by observing the pressure at which the slope of the curve becomes very large (approaches infinity). The results are given in Table II. For model 3, collapse actually occurred at the pressure given.

Calculated values compare favorably with the experimental values, especially when manufacturing tolerances and variations in the physical properties of the plastic radome models are taken in consideration. Eq (5) offers a good approximation for evaluating the effect of changing dimensions on the buckling strength of a shell structure.

Calculation of the absolute collapsing pressure for any arbitrary structure depends on the evaluation of the constant K and the equivalent length L_e. At present these must be determined experimentally for the particular shape. However, they do not have to be known to evaluate changes in thickness, shape, or material.

EDITOR'S NOTE—A comparison of buckling formulas for columns is given in "Column Formulas—Four Basic Types" April 1956 page 139. The article includes a chart showing combinations of formulas to use for different fields of applications.

Tubular members subjected to combined bending and torsion are usually designed by trial and error. However, a direct method for determining the dimensions for the tube of minimum weight to withstand a given combination of stresses is illustrated in "Design of Round Tubes for Combined Bending and Torsion" August 1955 page 205.

In "Graphical Method of Designing Thin-Walled Cylinders" October 1954 page 180, nomographs are given to quickly pinpoint combinations of dimensions that satisfy cylinders subjected to either torsion or bending.

An approximate method for determining the critical stress in thin-wall cylinders subjected to torsion is discussed in "Critical Buckling Shear Stresses in Thin Cylinders" April 1953 page 225. The article includes sample problems and a nomograph.

Brazing of Nodular Iron With Copper and Aluminum Bronze

USE OF COPPER AND ALUMINUM BRONZE as filler materials for the brazing of nodular iron has proved unsatisfactory as the result of tests conducted in Italy. The possibility of using aluminum bronze had been advanced in 1954 by Ball and Thorneycroft at the annual meeting of the Institute of British Foundrymen, and was based on the desirability of using low melting fillers with mechanical properties comparable to those of the parent metal. Low melting fillers have the advantage of minimizing the area of parent metal affected by heat, and reducing the amount of structural transformation in the nodular iron.

Nodular iron forms brittle compounds when brazed with copper or copper-rich alloys. Type of electrode used has little influence on the results. Fine cracking of the brittle compounds occurs upon cooling, causing early failure of the joint. Tensile strength of the joint is lower when aluminum bronze is used as the electrode than when pure copper is employed. Heat treatment does not improve joint properties to any appreciable degree.

In one series of tests, the temperature at the brazing point was kept under 1300 F where structural changes in the nodular iron begin to take place; but even this precaution did not prevent the formation of brittle compounds, indicating that alloying was taking place.

Massive inclusions of one metal in the other were also observed, and were ascribed to the agitation that takes place at the brazing surface. Inclusions of copper-rich alloy in the nodular iron occurred preferentially at locations previously occupied by graphite nodules. Occasionally the graphite nodule was surrounded by the copper-rich alloy.

The results of the experiments were published by Agostino Bargone, professor of special chemical technology, and Vittorio Gottardi, professor of metallurgy, both at the University of Padua. The report appears in Italian in the January-February 1956 issue of "La Saldatura Autogena," Piazza Franco Martelli, 3, Milano (Italy).

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Why Bearings FAIL

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Study of failures due to mechanical abuse, overload, neglect, application of improper lubricants, or imperfect manufacture, is an important guide to improved bearing design. Investigations of rolling and sliding bearing failures call for different and specialized knowledge of the behavior of each class of bearing. Use of a check chart is recommended in order to avoid overlooking both obvious and obscure causes, and to arrive more quickly at the correct remedy.

This article is a systematic description of the most common causes and remedies for sliding and rolling bearing failure. A trouble-shooting procedure is outlined and a check chart included that lists symptom, cause, and cure.

TROUBLE SHOOTING is one of the more complex features of work with bearings. It involves careful inspections, metallographic checks, design evaluations, mechanical and electrical studies, and chemical analyses together with a good, imaginative combination of the results of such efforts.

Installation and Maintenance

A careful study of installation and surroundings will often provide valuable clues as to the source of bearing difficulties. In many conventional machine designs, lubricants, and operating conditions have been well established by experience and in such cases any bearing trouble is likely to result from improper maintenance, dirt, humid or corrosive atmospheres, or peculiar load or vibrational conditions imposed on the machine. Such difficulties can often be determined almost immediately without any detailed analysis of the actual bearings and lubricants themselves.

Poor maintenance in itself is frequently the cause of bearing failures. Improper lubrication practices and schedules, or accumulation of dust, dirt and lint may be the primary cause. If so, the troubles with the bearings may appear not on one single position or a single machine, but in a rash of difficulties throughout the area. Inaccessability of oil cups, drain plugs and other lubrication fixtures may encourage poor maintenance. Poor storage facilities for lubricants may result in their contamination with dirt and water. Plant-wide use of inexpensive, uninhibited industrial oils may result in trouble with sludging, acidity, and insufficient load capacity in heavy duty machinery that requires high quality lubricants with properties specifically chosen for the application.

This article has been abstracted from two chapters of a book entitled, "Design and Application of Bearings," by Drs. Wilcock and Booser to be published by McGraw-Hill Book Co. in Oct. 1956.

Atmospheric surroundings about the installation should also be considered. High ambient temperatures increase the tendency for sludging of the oil, as well as loss of oil by leakage and evaporation. In general, the life of the lubricating oil is reduced by one-half for each 18 F increase in temperature. Many pieces of equipment are designed to run at ambient temperatures below about 125 F; if temperatures are higher than this, the temperature rise in a machine may heat the bearing above the 200 to 250 F generally permissible with conventional roller bearing steels and conventional lubricants. If the temperatures are suspected to be too high, they should be checked with thermometers in the area about the bearing, and possibly with thermocouples within the machine itself. A change in the machine design, a feed of cooling air to the bearing area, a switch from grease to forced oil circulation, or a switch to high temperature ball bearing steels and lubricants should be made if abnormaliy high temperatures are found to be present.

Water and very humid atmospheres often promote corrosion as well as breakdown and sludging of the lubricating oil. Bearing seals and shields themselves can do much to keep out the water under fairly severe conditions, and under extreme cases extra shielding and protection might have to be incorporated in the housing of the machine itself. Bearings operating under wet conditions should be well lubricated, either with a circulating forced feed oil system or with regular relubrication with a suitable grease. A suitable oil with a rust inhibitor should be selected and means should be provided for separating the water from the oil in the oil reservoir, in a centrifuge or in some filter.

Corrosive materials in the atmosphere are also detrimental. Gases of sulfur and chlorine and other chemicals are frequently corrosive to bearings and either should be eliminated with proper ventilation, or the oil and bearing material employed should be selected to be resistant to the action of the contaminated atmosphere.

ROLLING BEARING TROUBLE SHOOTING CHART

SYMPTOM AND CAUSE	REMEDY
A. Overheated Bearing	
1. Inadequate lubrication	Change to proper grease or oil. Adjust oil cup height, maintain oil level at center of lowest ball or roller. Fill grease housing ½ to ⅔ full. Clean oil holes, filters and vents. Use a fresh lubricant.
2. Excessive lubricant churning	Use lower viscosity oil, lower oil level to center of bottom ball or roller, fill grease housing only half full, use oil mist.
3. Inadequate internal clearance	Use bearing of greater looseness, allow for differential thermal expansion, reduce interference of shaft and housing fits, correct any housing out-of-roundness or warping.
4. High seal friction	Stretch felt or use reduced spring tension with leather or composition seals, lubricate seals, switch from rubbing seal to low clearance shield.
5. Excessive preloading	Use gaskets or shims to relieve axial preload with opposed pair or with two held bearings on a shaft subjected to thermal expansion. Change design to use only one held bearing.
6. Spinning outer ring	Use closer housing fit, use steel insert in soft aluminum housing, use garter spring or rubber holding ring.
7. Misalignment	Correct alignment by shimming pillow blocks, housings or machines to get shafts and bearings in line. Check for misalignment of bearing seats and shaft and housing shoulders.
B. Noisy Bearing, Vibration	
1. Wrong type of grease or oil	Check manufacturer's recommendations and those of lubricant supplier. A higher viscosity oil or a better feeding grease with a higher viscosity oil may help.
2. Insufficient lubrication	(See A. 1)
3. Defective bearing	Check for brinelling, fatigue, wear, groove wobble, poor cage. Replace bearing.
4. Dirt	Clean bearing housing, replace worn seals, improve seal arrangement, eliminate source of dirt.
5. Corrosion	Improve sealing to keep out corrosive elements, use corrosion resisting lubricant.
6. Too great internal clearance	Change to bearing with smaller clearance.
7. Unbalance	Balance rotor.
8. Misalignment	Align (See A. 7)
9. Too loose shaft or housing fit	Build up shaft or bore with chrome plate or metallizing and regrind.
10. Improper mounting	Correct dirty or off-square shaft and housing shoulders and seats. Avoid brinelling caused by pounding on bearing.
11. False brinelling	Use vibration mounts for machine to isolate from platform during idle periods.
12. Seal rub	Check for metal bearing seal or shield rubbing on shaft, shaft shoulder or housing.
C. Loss of Lubricant	
1. Oil leakage through seal	Adjust oil level to center of lowest ball or roller, replace seal, use double seal arrangement with drain between, eliminate any unfavorable air flow by proper baffles and balancing channels.
2. Leakage at housing split	Use thin layer of gasket cement, replace housing.
3. Grease leakage	Pack housing only ½ to ⅔ full, use channeling type grease, eliminate any pressure causing air flow through bearing, keep solvents or water from entering and softening grease, use new or improved seals.
4. Dry, caked residue	Use silicone or other high temperature grease, use oxidation inhibited or synthetic oil or grease, cool oil in external cooler, cool bearing housing, increase oil flow to promote cooling.
D. Loose Bearing	
1. Shaft diameter too small	Turn down shaft, chrome plate or metallize and regrind to give proper fit. Retighten adapter to get firm grip on shaft.
2. Housing bore too large	Build up bore with chrome plate or metallizing and regrind, bore out housing and press in sleeve to give proper bearing fit. (A slip fit on OD is usually desirable to allow for differential axial thermal expansion of a shaft between two bearings).
E. Hard Turning of Shaft	
1. Excessive bearing preload	Use less interference fit on shaft or in housing, select bearing with greater internal clearance where heat conduction expands shaft and inner bearing ring. Relieve axial preloading by housing shims either with two opposed bearings or two "held" bearings on one shaft.
2. Heavy seal rub	Stretch felt seals to reduce their friction, use reduced spring tension on leather or composition seals, scrape out ID of rubber seals, use a shield with clearance on the shaft.
3. Dirt	Clean housing and use fresh lubricant (See B. 4).
4. Corrosion	(See B. 5).
5. Lack of lubrication	Raise oil level to center of lowest ball or roller, grease pack housing half full. Eliminate possibility for loss of lubricant by leakage.
6. Incorrect lubricant	Use softer grease or thinner oil.
7. Bearing pinching or cocking	Scrape housing bore to relieve pinching. Replace or remachine warped housings, check bearing seats as source of cocking.

With either moisture or corrosive gases present, some consideration should be given to 440C stainless steel ball bearings. Although they give much better resistance to rusting and corrosion than do the normal ball and roller bearings, the chrome content is not sufficient to make them completely stainless and fatigue properties are not as good as those of the usual 52100 type of steels.

Dirt should be avoided wherever possible. If it cannot be avoided, precautions should be taken in the bearing housing, bearing seals, and lubricating oil system to minimize the effect of the dirt. Extensive work has led to seals for greased ball bearings which are now satisfactory for many types of operations around mineral processing plants, in chemical plants, and for mining and earth-moving projects. The dirt is harmful both in causing abnormally great wear of the bearing itself as well as in thickening of the lubricating oil and interfering with its flow through tubes, orifices, pumps, wicks, and oil rings. A final resort in some dirty systems is to supply clean air under a slight positive pressure to bearing housing chambers and oil reservoirs so that any air circulation taking place is of the clean air inside going out, rather than of dirty air from the exterior coming into the oil and bearing. For less severe conditions, the use of rubbing seals or greased ball bearings with grease in the clearance space between seals and shafts may prove adequate.

Vibration of the machine should be checked with a mechanical or electrical vibration pickup. If the frequency of vibration is that of the rotor, the rotor balance should be checked; while whirl or whip in high speed machinery at a frequency of either the first vibrational critical of the rotor or at one-half the rotational speed of the shaft would suggest a more stable bearing design. Strain gages and other instrumentation should be employed on machine elements and housing and mounting surfaces around the bearing if there is a question of the load being applied.

Electrical voltage potential of the shaft (while running)

SLIDING BEARING TROUBLE SHOOTING CHART

SYMPTOM AND CAUSE	REMEDY
A. Wear, Scoring, Galling	
1. Dirt	Change oil, install new filter, remove source of contaminant, provide flushing chamfers at end of oil grooves, use softer bearing material to embed small amounts of dirt or a harder journal to reduce its effect.
2. Misalignment	Align journal with bearing.
3. Excessive journal deflection	Provide adequate journal support, reduce load causing deflection.
4. Boundary-film condition	Increase oil viscosity, use anti-wear or extreme pressure oil or grease, change to bearing material with better compatibility, change bearing design for greater oil film thickness.
5. Too low oil viscosity	Use heavier viscosity oil. Reduce bearing operating temperature by cooling oil, increase oil flow to lower the bearing temperature, modify bearing design to give higher load capacity.
6. Rough Journal	Polish or grind journal.
7. Poor bearing-journal material combination	Select compatible materials, increase shaft hardness or use hardened sleeve on shaft. Use additive type oils.
8. Load too high	Increase oil viscosity, increase bearing size, use stronger bearing material with hardened shaft, use anti-wear or extreme pressure oil.
9. Vibration	Balance rotor, increase oil viscosity, use pressure bearing, 3-lobe or elliptical type.
10. Journal Eccentricity	Replace journal.
11. Improper grooving	Take grooves out of loaded zone in bearing.
12. Electrical Pitting	Remove source of current flowing through bearing, electrically insulate bearing, ground journal.
13. Insufficient Lubrication	Add oil; check pump, filter, cooler, piping; increase oil inlet pressure.
B. Corrosion	
1. Corrosive contamination	Remove contamination source, atmospheric or otherwise. Seal bearing, use corrosion resistant lubrication.
2. Moisture	Use rust inhibited oil, remove source of moisture.
3. Corrosive lubricant	Change oil or grease periodically to avoid build-up of corrosive oxidation products, avoid possibly corrosive extreme pressure oils if not necessary, change to non-corrodable bearing material such as tin babbitt or aluminum.
C. Overheating	
1. Insufficient Oil Film	Increase bearing clearance, decrease oil viscosity, add more oil distributing grooves, increase supply pressure, increase oil orifice size, increase chamfer size.
2. Improper oil viscosity	Change to proper viscosity for bearing load, speed, and temperature.
3. Too little clearance	Scrape or machine out bearing bore.
4. Heat from surroundings	Provide circulating oil system with external cooling, increase oil flow, use heavier oil, water cooling, insulate bearing, reduce ambient temperature with better ventilation.
5. High Load	Reduce load and belt tension, use compounded oil containing oiliness or E. P. agents. Change to stronger bearing material and a bearing designed for higher loads.
6. High Speed	Decrease oil viscosity, increase clearance and oil flow. Change to elliptical, overshot or multigroove bearing, decrease journal size.
D. Fatigue	
1. Overload	Use larger bearing, reduce load, use stronger bearing material.
2. Edge loading	Correct shaft deflections, correct bearing alignment, check machining of bearing and journal.
3. Local high stress concentration	Check for corrosion factors, electrical pits, rough surface finish. Use higher viscosity oil.
4. High bearing temperature	Reduce operating temperature, use heavier oil, change bearing design for higher oil flow, change to higher temperature bearing material.
5. Rotor vibration	Balance rotor, use stabilizing bearing design of elliptical, pressure, or 3-lobe type. Change rotor support to damp out vibration.
6. Cavitation erosion	Relocate oil holes and grooving, use higher viscosity oil and lower bearing temperature, use fatigue resistant bearing material.
E. Seizure	
1. Too little clearance	Provide adequate clearance, taking into account any temperature effects and thermal expansion.
2. Insufficient lubrication	Supply larger amounts of oil, use higher viscosity oil; use extreme pressure lubricant; use proper design of oil feed grooves and orifices.
3. Too high load	Increase bearing area and modify bearing design to carry load; use higher viscosity oil, use compounded oil.
4. Overheating	Provide external cooling and ample oil flow.
5. Unsuitable bearing material	Use more compatible bearing material with satisfactory strength and thermal properties.

should be checked with an electronic or high resistance voltmeter. To get satisfactory indications it is usually desirable to isolate the bearing housing or the entire machine from contact with ground. Voltages above about 1 or 2 volts will generally cause pitting and wear of the bearing and journal with eventual breakdown.

The oil system may be the cause of bearing troubles. Sludge deposits plugging the filter or piping, rusting of the oil cooler, water or foam in the oil tanks, dirt, an inadequate supply of oil, a malfunctioning pressure relief valve, or a pump failure can all result in bearing failure.

Poor alignment of bearings or of bearing supports, cocking of a thrust runner, or a bent shaft will also cause trouble and will show up in a wiping or wear of the overloaded portions of the bearings. Pinching and distortion of the bearing on installation, loss of clearance because of differential thermal expansion, an oversize shaft, improper location of the oil grooves in the load support area of the bearing, or a rough shaft should also be looked for.

Rolling bearing misalignment can come from any one of the three general situations shown in Fig. 1. The bearings in the machine may be out of line, either the outer or the inner ring of the bearing may be cocked or tilted, and there may be deflection of a shaft. Carefully calibrated micrometers and dial indicators, along with appropriate accessory mounting and clamping facilities should be used for misalignment checks. Actually the out-of-line situation rarely causes trouble in a ball bearing. The usual single row, deep groove ball bearing can withstand ¼ deg angular misalignment without cramping or binding. This corresponds to 1/16 in. per foot, and a shaft a foot long out of line by more than 1/16 in. would be unusual.

Much more common is a bearing housing or the housing shoulder tilted or off-square. An off-square seat for the inner bearing ring is also common. The same effect is created by off-square lockwashers and locknuts holding the bearing inner ring. On a 1 in. diameter shaft a 0.005 in. off-square shoulder corresponds to ¼ deg misalignment, so difficulties with tilted inner and outer bearing rings are not uncommon. Deflections of a shaft are rarely critical because many shafts would break before their angularity at the bearing reaches ¼ deg. Nevertheless, all of these factors should be checked in the case of bearing difficulty, particularly if the ball path in the bearing indicates misalignment. If such troubles do exist, the necessary changes in tolerances in manufacturing, improved inspection procedures, or appropriate design changes should be made to eliminate the difficulty.

Along with checks for misalignment, checks should be made of the fits in the housing and on the shaft to see that these correspond with the manufacturer's recommendation.

Lubrication Analysis

Detailed examination of the lubricating oil or grease and the lubrication system is as important as a bearing examination in the case of a failure. Frequently, failures which might normally be attributed to improper bearing design or machine usage actually result from such factors as dirt in the oil stream, dirty filters, acidic oil, insufficient oil flow, or use of an improper grade of lubricant. Even where the lubricant and its circulating system are not at fault in a bearing failure, evidence from the type of wear particles in the oil and consideration of the oil properties can often be of value in leading the way to a clearer understanding of the source of the trouble.

Sliding Bearing Oil System Analysis

A step by step analysis of the lubricating system should be made. Visual examination of the oil for suspended wear particles, rancid odors, darkening, and possible traces of water, fuel and solvents should be a starting point. A sample should be taken for a more detailed laboratory analysis.

Checks should be made at critical points in the lubrication system for: sediment and water at the bottom of the oil reservoir; too low an oil level; leaks, corrosion, or plugging of the cooler; air locking of the pump intake; sludge, varnish, or rust build-up to interfere with oil flow through pipes, valves, orifices, and pumps; a satisfactory temperature and pressure level in the oil lines; and degree of foam build-up in the reservoir.

Detailed examination of a lubricating oil from a unit in which bearing troubles have been experienced should be directed at the following four factors: (1) to establish the identity of the product and determine if it has the correct physical properties called for in the installation; (2) to establish the degree and nature of any contamination; (3) to determine if the oil still has the characteristics essential for continued satisfactory use; and (4) to establish the reasons for unsatisfactory performance in the bearings and possibly other mechanisms.

Viscosity is of primary importance among the properties to be considered in selecting lubricants for use in journal bearings. A check of the viscosity of used oil at 100 F and 210 F is also useful in trouble shooting. The results will indicate if the proper viscosity grade of lubricant was initially present in the machine.

A very low viscosity may indicate dilution by fuels or solvents. A higher viscosity level than would be expected for the type of oil involved might suggest that the oil is badly oxidized. If dirt and contamination are present in the oil being used for a viscosity check, samples should first be cleaned of solid impurities by passing it through a sintered glass filter or by centrifuging out solid particles. Viscosity index of the oil obtained from viscosity measurements at two temperatures will also give an indication of oil quality. The better oils usually change less in viscosity with varying temperatures and thus have a higher viscosity index.

Acidity as measured in the neutralization number test is generally the second most useful information on a used oil. A neutralization number usually gives a good idea of the degree of oxidation. Since insoluble matter, corrosivity, varnish deposits, and viscosity all tend to build up rapidly as oil reacts with oxygen of the air, a high neutralization number should be taken as an indication that the oil was in service too long and should have been changed.

In steam turbines and other large industrial units where a large circulating oil supply is involved, the neutralization number is frequently best kept at a level below about 0.5 milligrams of KOH per gram of oil. In other industrial ap-

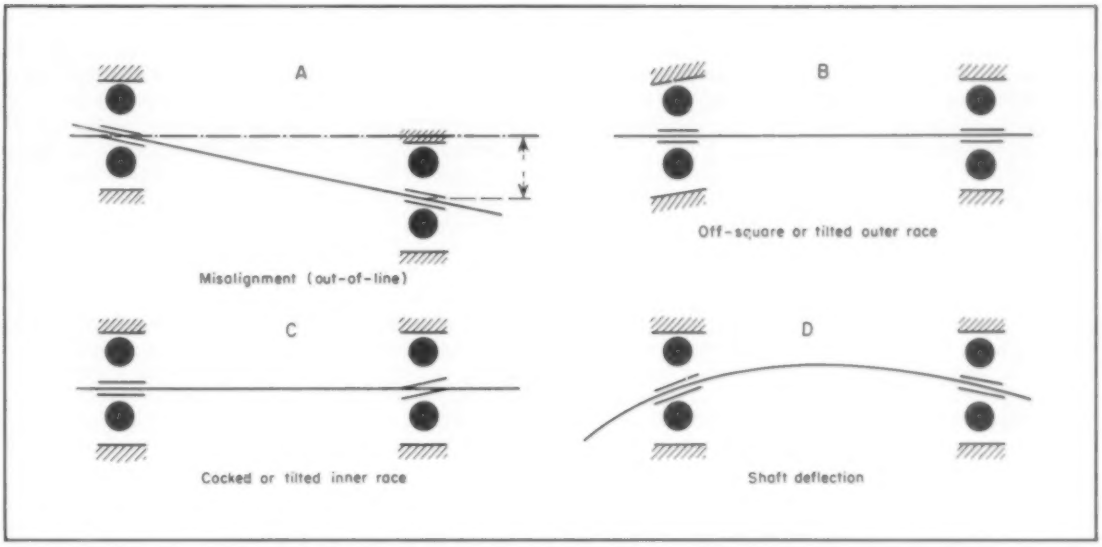


Fig. 1 — Four types of misalignment to which rolling bearings may be subjected. Marlin-Rockwell Corp. (Ref. 4)

plications where the neutralization number and the degree of oxidation of the oil is not so critical, the neutralization number may rise to a value of about 2.0 before a change would be necessary. In automotive service neutralization numbers may sometimes go as high as 5.0 or more without any particular harm to the engine being apparent. Some of the new synthetic diester oils sometimes may have satisfactory lubricating properties even when the neutralization number reaches a level of about 13 to 15.

Keeping in mind that the neutralization number itself is frequently not critical since the high molecular weight organic acids formed in the oxidized oil are not corrosive to most materials in the lubricating system, values above about 2.0 should be regarded with some question. Above this value, there may be trouble with varnish deposits, sludge formation and operating difficulties such as plugged filters, poor oil circulation, and corrosion of lead, cadmium, copper, and zinc bearings.

Tests for types of contaminants present in lubricating oil are also of very great importance. If solid metal particles are found in a lubricating oil system, their analysis may quickly lead to the bearing or other mechanical part where wear is taking place. Any corrosion of bearing materials or other machine parts by lubricating oil will bring into the lubricating oil stream soaps of the corroded metals. Water can form insoluble products with additives present in some types of lubricating oils. Analysis of contaminants should give some clue as to source and means for elimination.

Many analytical tools are now available for studying the contamination of lubricating oils. The fastest and quickest for initial screening tests is the emission spectrograph. A sample of the oil, or preferably a concentrated sample of the contaminant, is arced and the wave length of light emitted from the spark indicates the elements present. Thus, a large amount of copper might indicate corrosion of copper bearings, wear of a bronze pump or corrosion of copper oil lines; and the presence of steel might indicate wear of sliding steel parts such as the piston rings in automotive engines. Chemical spot checks also give a quick indication of the type of materials involved in contaminants. An electron diffraction study may even provide exact indication of the chemical compound or alloy structure of the contaminant.

Contamination by fuels or solvents will show up as a low flash point, and if fuel dilution is suspected, a direct check should be made for it. A check on the amount of water at the lowest point in the oil reservoir will give a good idea as to the quantity present.

An ASTM oil oxidation test is useful in giving some idea of the relative period of operation which might be expected before acidity and sludge will rise to an unacceptable value. If a new oil had an oxidation life of 1000 hr, for instance, and the sample of used oil tested had an oxidation life of 500 hr, the oil might be considered satisfactory for use for a period totalling twice that elapsed up to the time of sampling. A check on the rusting characteristics of the oil and its foaming tendencies would be advisable in cases where these properties are considered important for proper functioning of the machinery.

Roller Bearing Grease Analysis

Oil content of the grease in bearing housing, as well as acidity of the oil will be the two most valuable indications as to the breakdown of a grease in a bearing. An oil content analysis of a variety of samples of greases from different sizes of failed laboratory bearings operating under a number of conditions is indicated in Fig. 2. A critical minimum oil content of about 50 to 60 per cent by weight has been found with many different greases in applications ranging from fractional horsepower motors to railway traction motor bearings. This limit would be expected to vary, however, and a much higher oil content would be necessary, for instance, with railway journal bearings.

A useful method for determining oil content in small samples of used greases is as follows: Weigh approximately 0.10 grams of grease into a double-thickness micro Soxhlet fat-free paper thimble. Insert the thimble into the micro

Soxhlet extractor. Add 15 ml benzene to a tared extraction flask and assemble. Extract the oil over a water bath for approximately one hour; then remove the extracting flask and evaporate the benzene. Dry in a 100 C oven for ½ hr, cool and weigh the oil.

If there is an excess of fats and fatty acids in the grease, the benzene extract should be saponified by refluxing with 15 ml of 0.05N alcoholic KOH, filtered, separated in a separatory funnel, washed with ethyl alcohol and dried.

In addition to an oil content analysis, an acidity check will give an indication of the degree of deterioration of a used grease. To eliminate interference by soap, the oil is first extracted from the grease with diethyl ether. The ether solution is then diluted with alcohol and a little water and titrated with alcoholic base. The acid numbers (milligrams of KOH per gram of grease) found in samples from failed bearings range from 5 to 15. Although a ball bearing may run satisfactorily even with an acid grease, acidity will provide a measure of the degree of oxidation.

An analysis of the used grease with an emission spectrograph will also help indicate the nature of any contaminants present. For such an analysis, a pinhead of grease is usually sufficient as a sample to be flashed in the spectrograph. The resulting emission lines can be checked against the known spectra of metallic elements to determine which elements were present in the grease sample. This will both give a check on the soap type as well as the metallic type of any dirt or contamination present in the grease in the bearing housing. By so doing it may well indicate the source of dirt causing trouble.

A sample of the grease may also be smeared in a thin layer on a glass slide and examined under a microscope. Lint, fibers, and solid dirt may be identified in this way.

In addition to these laboratory checks, a simple visual observation should be made of the condition of the grease. All greases darken as they deteriorate, and pending failure with a given type of grease may be associated with a particular color. As greases oxidize, they generally become rancid, and the odor of a grease in a bearing housing may give some indication of its remaining life. The consistency of the grease should also be observed. If it is extremely dry and channeled and does not seem to be feeding into the bearing, lubrication failure may result for high speed units. If it appears exceptionally soft, it may be feeding into the bearing in too great quantities and causing high friction with a correspondingly high temperature rise.

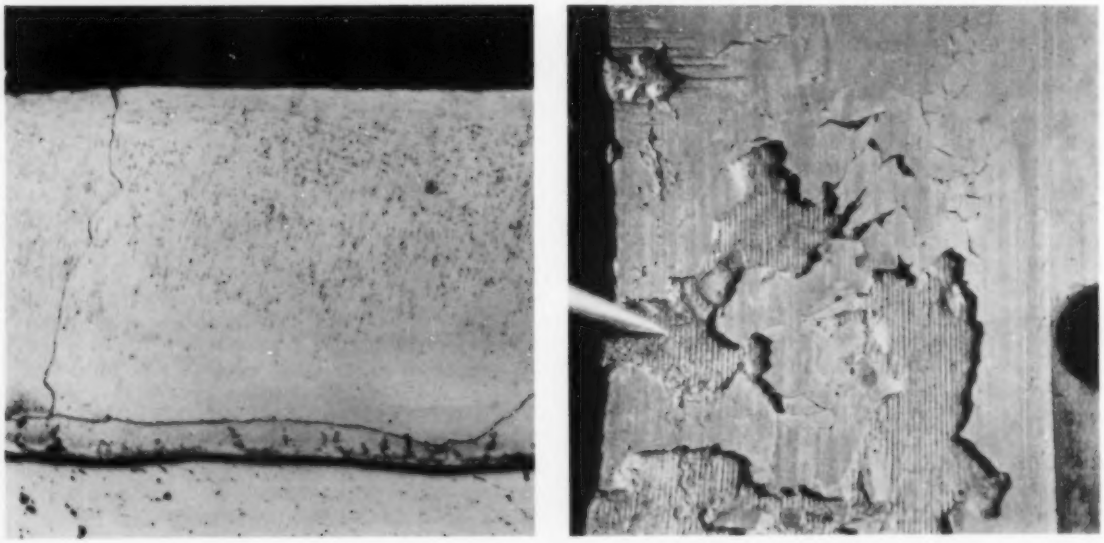
Failure of Sliding Bearings

The relatively limited number of mechanisms by which a bearing may encounter trouble can frequently be identified by simple visual and microscopic examination of the bearing surface. Supplementary studies by electrographic spot testing, X-ray defraction analysis, various chemical analyses, and hardness checking may also be useful supplements to a visual inspection.

Fatigue

Fatigue is one of the most common diseases of bearings in automobile, aircraft and diesel engines. Since the reciprocating nature of the load cannot be avoided, fatigue failures in such cases can be averted only by the selection of the proper bearing materials for the application involved.

Fig. 3 – (A) Fatigue crack running down through the babbitt and then along, but definitely above, the bond layer which appears as a broad dark line. (B) Spalled areas resulting from fatigue which leave a thin layer of soft bearing metal still on the backing. (Ref. 5)



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Once started, fatigue is a self-accelerating phenomenon. The loose material provided by the initial fatigue breakdown is transferred to other parts of the same bearing and to other bearings. These loose particles then generate localized stress concentrations and hot spots elsewhere and promote further fatigue. In this fashion, bearing clearances are also locally lowered, unit loadings and temperature locally increased, and a complete bearing failure follows.

Fatigue failures are frequently induced by mechanical troubles such as mislignment, edge loading of the bearing, a tapered or bent shaft, improper assembly, dirt or chips in the oil stream, improper lubrication, or use of improper lubricants. Any of these factors may be responsible either by providing the proper conditions for high stress concentration to promote fatigue or by raising the temperature and thus lowering the fatigue life of the bearing material.

Poor bonding of the bearing surface layer to the bearing shell may also be responsible for premature fatigue failures. In such cases, any fatigue cracks are propagated rapidly along the juncture between the bearing material and its backing with the resultant spalling out of large pieces of the bearing metal as shown in Fig. 4. If the bearing material has been well bonded to the bearing shell, a thin surface layer of the bearing material will be left adhering to the shell under fatigue cracks. This factor may be used to determine whether or not poor bonding contributed to the fatigue failure. The bonding of babbitt on steel strip bearings may be checked by soaking them in hot oil at 300 F. Any imperfections in the bonding will show up as blisters in the babbitt surface after such a treatment.

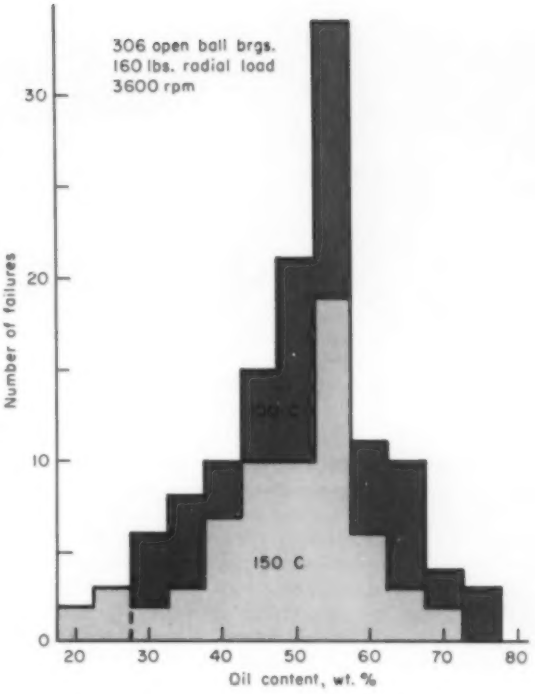

Fig. 2 — Oil content of petroleum greases at failure. (Ref. 3)

Fig. 4 — Large spalled area in which the lack of bearing metal on the exposed backing metal is evidence of a bond failure. (Ref. 5)

Corrosion will also contribute to weakening and fatigue of some types, such as copper-lead bearings, by selective removal of one of the microconstituents. Attack by corrosive contaminants in an oil or by a corrosive oil itself may also cause embrittlement of bearing material. Microstructure, x-ray diffraction, and chemical analyses should show some change in the material composition, which would not be the case for simple fatigue failure.

Scoring, Wiping and Seizure

Where reciprocating loads and alternating stresses are not present to induce fatigue failures, the most frequent causes of difficulty are associated with an inadequate oil film and actual rubbing of the journal or thrust runner on the bearing surface.

Wiping, as shown in Fig. 5, usually results from rubbing a shaft on a soft bearing material such as babbitt when there is at least a temporary discontinuity in the oil film. Such a condition may be encountered during initial running of a machine in which there is some misalignment, pinching of the bearing, insufficient clearance or some other geometrical defect in the bearing or journal. Wiping of bearing material, particularly if it is one of the babbitts, gen-

Soxhlet extractor. Add 15 ml benzene to a tared extraction flask and assemble. Extract the oil over a water bath for approximately one hour; then remove the extracting flask and evaporate the benzene. Dry in a 100 C oven for ½ hr, cool and weigh the oil.

If there is an excess of fats and fatty acids in the grease, the benzene extract should be saponified by refluxing with 15 ml of 0.05N alcoholic KOH, filtered, separated in a separatory funnel, washed with ethyl alcohol and dried.

In addition to an oil content analysis, an acidity check will give an indication of the degree of deterioration of a used grease. To eliminate interference by soap, the oil is first extracted from the grease with diethyl ether. The ether solution is then diluted with alcohol and a little water and titrated with alcoholic base. The acid numbers (milligrams of KOH per gram of grease) found in samples from failed bearings range from 5 to 15. Although a ball bearing may run satisfactorily even with an acid grease, acidity will provide a measure of the degree of oxidation.

An analysis of the used grease with an emission spectrograph will also help indicate the nature of any contaminants present. For such an analysis, a pinhead of grease is usually sufficient as a sample to be flashed in the spectrograph. The resulting emission lines can be checked against the known spectra of metallic elements to determine which elements were present in the grease sample. This will both give a check on the soap type as well as the metallic type of any dirt or contamination present in the grease in the bearing housing. By so doing it may well indicate the source of dirt causing trouble.

A sample of the grease may also be smeared in a thin layer on a glass slide and examined under a microscope. Lint, fibers, and solid dirt may be identified in this way.

In addition to these laboratory checks, a simple visual observation should be made of the condition of the grease. All greases darken as they deteriorate, and pending failure with a given type of grease may be associated with a particular color. As greases oxidize, they generally become rancid, and the odor of a grease in a bearing housing may give some indication of its remaining life. The consistency of the grease should also be observed. If it is extremely dry and channeled and does not seem to be feeding into the bearing, lubrication failure may result for high speed units. If it appears exceptionally soft, it may be feeding into the bearing in too great quantities and causing high friction with a correspondingly high temperature rise.

Failure of Sliding Bearings

The relatively limited number of mechanisms by which a bearing may encounter trouble can frequently be identified by simple visual and microscopic examination of the bearing surface. Supplementary studies by electrographic spot testing, X-ray defraction analysis, various chemical analyses, and hardness checking may also be useful supplements to a visual inspection.

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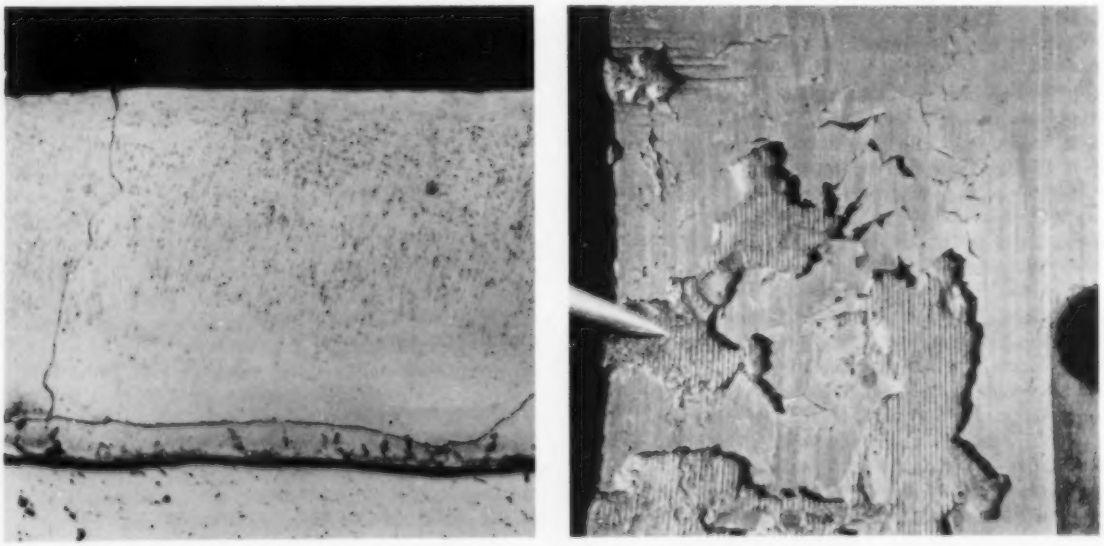

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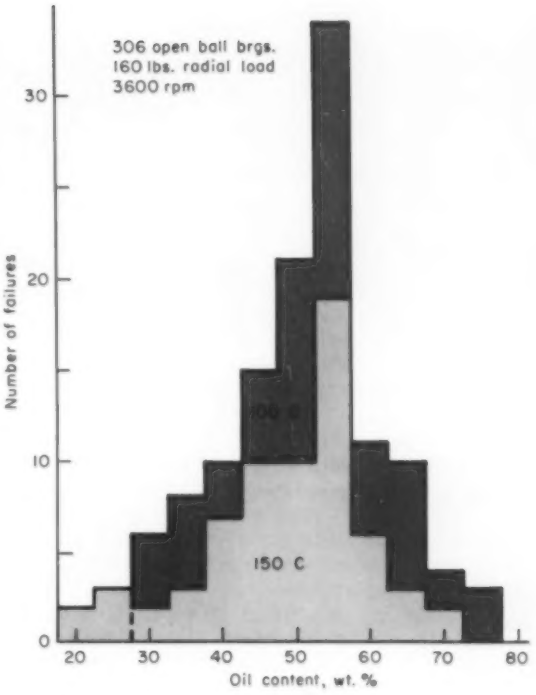

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Fig. 5 – Wiping resulting from insufficient initial clearance. Cleveland Graphite Bronze Co. (Ref. 8)

erally provides sufficient clearance or conformity so that further operation will be possible with complete satisfaction. Slow run-in periods are generally desirable so that wiping action may take place without the generation of extremely high temperatures which would destroy the bearing.

With harder bearing materials such as the bronzes, failure of the oil film generally results in scoring of both the bearing surface and journal. Relatively hard particles torn from the bearing surface by initial contact promote scoring and scratching of surfaces rather than simple wiping encountered with babbitt.

Machine design, lubricant, and lubrication system should all be selected to provide a lubricant film that will completely separate journal from bearing surface. If this is impossible, chemically active extreme pressure additives or solid lubricants such as graphite and molybdenum disulfide suspended in oil and bearing materials with good compatability properties should be selected.

Wear

Various factors can contribute toward a much slower wearing away of the metal from the surface of a bearing than is encountered in the wiping and scoring discussed above. Gradual mechanical wear occurs in any bearing in which the journal and bearing surface are not separated by a lubricant film, but in which the design, lubricant, and materials are selected so that there is no extensive or sudden destruction of the bearing surface. Starting and stopping, high loads, very low viscosity oils, high operating temperatures, and vibration may contribute to conditions where there would be such mechanical wear.

Wear may also be simply a mild abrasion in which dirt particles passing through the bearing slowly remove a portion of the surface. Similarly, corrosion by contaminants in the oil or by oxidized oil itself may cause wear. Wear under these conditions may be minimized by the proper selection of bearing materials and designs. The deleterious effect of dirt particles can best be avoided by designing the bearing to run with a large clearance, by use of grooving designs which continually flush dirt out of the bearing, and by employing a bearing material which will readily embed hard particles. Corrosive wear may be avoided by use of some bearing material which is not attacked by the oil or any contaminants in it.

Electric Currents

Destructive current flows ranging from those of the order of about 1 milliampere upward will flow through most journal bearings when the potential drop from the journal to the bearing is of the order of 1 volt or higher. Sparks pass through the oil film and cause microscopic pits in the surface of the journal and the bearing. This action results in a continual removal of metal from the surface of the bearing and troubles may be noticed in periods ranging from a few hours up to several years depending upon the magnitude of the current flow.

Electrical wear shows up as a frosted surface in the loaded zone of the bearing where the oil film is thinnest. Under a microscope the frosted area will appear as a multitude of small craters. These craters each result from the fusing temperature generated by the passage of an electrical spark. The surface of a bearing pitted by electric current flow is shown in Fig. 6.

Changes in bearing design, bearing materials or lubricants are ineffective in helping avoid the wear from passage of electrical currents. However, there are several methods by which current can be prevented from flowing through the oil film. The bearing may be insulated from its housing by an insulating lining such as of a phenolic plastic. A grounding brush may be applied to the shaft to provide a lower resistance path for the current to go around the bearing. Most effective, although frequently difficult to accomplish with an installed unit, is the actual elimination of the cause of the potential drop across the bearing. An analysis of the electrical system associated with the unit in which the bearing is located, together with a consideration of possible sources of stray currents or of static charges building up on the rotor, may lead the way to such an elimination of the voltage source.

Abrasion

Circumferential scratches of the bearing surface and embedded hard particles, as shown in Fig. 7 are characteristic of abrasion. The nature of this scratching may vary from an almost microscopic effect with very fine particles which results in slow wear, to the other extreme of severe scoring which may be encountered with large abrasive dirt particles.

Abrasion may be differentiated from scoring or simple

Fig. 6 – Pits formed by passage of electric current through a large babbitt bearing.

Fig. 7 – Hard dirt particles have caused scratches and sharp edged indentations. (Ref. 5)

wear as discussed previously by the presence of foreign particles in the surface of bearing materials. Careful probing with a pick, microscopic examination, and chemical spot testing are all valuable tools in determining the nature of and identifying the abrasive material. Once identification is made, the source of the foreign material may frequently be removed. If this proves impossible, the dirt should be excluded as completely as possible by careful filtration of the oil coming into the bearing as well as by use of positive sealing of the bearing housing to prevent the ingress of air-borne matter.

Effects of abrasive material may be minimized by using (1) a hardened shaft and as soft a bearing material as possible to give maximum embeddability, (2) large oil film thickness between the journal and bearing with a high viscosity oil and lightly loaded bearing surface, and (3) grooving of the bearing so as to provide a maximum flushing action to disperse solid particles from within the bearing and avoid collection in pockets at dams and in oil grooves.

Corrosion

The corrosion of a bearing results from attack by reactive chemical materials in the oil stream. These reactive chemicals may be corrosive materials picked up by the oil from the surroundings, or they may be oxidation products or reactive chemical additives in the oil itself. Fig. 8 shows the selective corrosion of the lead in a copper-lead bearing.

Probably the most widespread source of corrosive attack is the oxidation products formed in oil itself. By reaction with the oxygen of the air, oil is gradually transformed to various organic acids and peroxides that corrode a number of the more common bearing materials such as those containing lead, copper, cadmium, and zinc. Tin babbitt, aluminum, and silver are not normally affected by these oxidation products.

Corrosion of lead bearing materials is the most troublesome, both because of the very extensive use of lead as a bearing material in babbitts and in copper-lead bearings, as well as because of the relatively rapid reaction of lead with oil oxidation products. Lead surfaces are readily oxidized by the organic peroxides present in oxidized oil and then these surface oxides are, in turn, dissolved away by organic acids present in the oil.

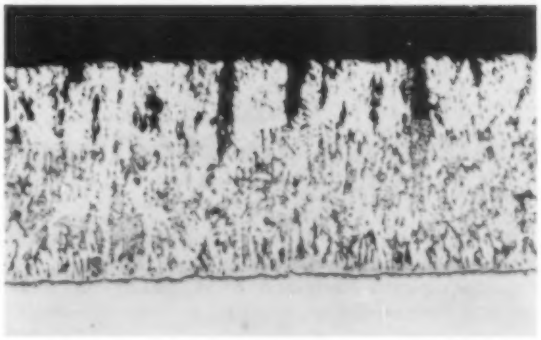


Fig. 8 – Copper-lead bearing from which the lead has been corroded to leave dark colored voids at the top where the light copper grains still remain. (Ref. 5)

Difficulties with this form of corrosion have now been largely eliminated. The use of oxidation inhibitors in the oil, protective alloying elements in lead babbitt such as 7 or 8 per cent of tin, indium coatings over the lead, and periodic oil changes have all contributed greatly to minimize any difficulty with corrosion. Such measures have been successful to the degree that lead babbitt is now the most widely used of all bearing alloys and excellent use is being made of its fine bearing properties in many types of difficult applications. Despite this general success with lead babbitt, tin babbitt or aluminum should be considered for use where corrosion may be a problem.

The additives present in oils also contribute to corrosion in some cases. Sulfur compounds are added to many oils to provide extreme pressure properties as well as to avoid scoring and welding under heavy loads. These extreme pressure properties are provided by an essentially corrosive action of the sulfur compounds of the oil on the steel or bronze bearing surfaces. During the corrosion, a low shear strength surface layer is formed over the bearing material so as to prevent welding and destructive contact with the journal material. This corrosion, although normally not rapid enough to be troublesome, does continue slowly even under normal operating conditions. For this reason, oils of the extreme pressure type should be avoided for

normal applications and should be employed only where specific extreme load-carrying properties are necessary.

Corrosive contaminants in the surrounding atmosphere may also cause corrosion. Chlorine and sulfur acids, particularly when some moisture is present, will corrode many bearing materials.

Erosion

Erosion is probably the most infrequent of all the causes of bearing difficulties listed here. It consists primarily of a mechanical washing away of the bearing surface by the oil stream between the journal and the bearing. The formation and collapse of air bubbles within the oil can lead to extremely high localized pressures which result in localized fatigue and pitting of the bearing surface by "cavitation erosion" as shown in Fig. 9.

Changes in the design of the grooving of the bearing is usually the most effective way to combat erosion. In changing the grooving and other features of the bearing geometry, the velocity of the oil stream should be reduced if possible and points of sudden alterations in the oil flow pattern in the oil film should be avoided. Use of a thin layer of 0.001 to 0.002 inches of babbitt on a steel backing will often eliminate cavitation erosion of the bearings in gear sets. Some spur gears are especially troublesome in giving an oscillating bearing load and a shaft motion which leads to the generation and collapse of air bubbles within the oil film.

Fig. 9 — Cavitation erosion in gear train bushing. Cleveland Graphite Bronze Co. (Ref. 8)

Failures in Rolling Bearings

A large portion of the failures of ball and roller bearings in industrial equipment result from insufficient lubrication. When the supply of lubricant is too low, sliding friction becomes destructive with the following sequence of events:

1. Localized heating at rubbing areas.
2. Loss of radial play arising from differential thermal expansion caused by excessive friction.
3. Internal loading.
4. Softening of balls and races with burning of the surfaces.
5. Jamming of the bearing and, finally, cage demolition.

If sufficient power is available, the bearing may be forced to run even beyond these steps with excessive damage to the shaft and housing of the machine itself.

Overheating resulting from the churning of excess grease frequently leads to a bearing "failure" and a replacement, even though the bearing itself may still be in good condition. Excessive heating, expansion, churning and leakage of grease in an overpacked bearing may also cause an early failure from lack of lubrication. For best results, an ordinary grease cavity for an open ball bearing should be packed only about one-half to two-thirds full to avoid this type of failure.

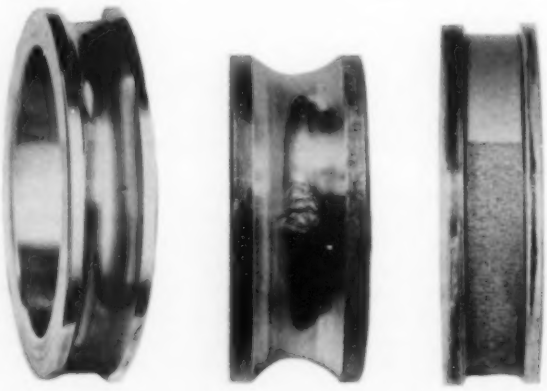
Smearing of the raceway surfaces and the cage rubbing surfaces from lack of lubrication is shown in Fig. 10. Severity of the damage will vary from scuffing of raceways and some smearing of rubbing surfaces of cages in early stages of a lubrication failure, to completely demolished parts as the final stage.

A pressure drop across a double sealed or shielded bearing may cause a loss of the grease and a failure. Openings in the bearing support to allow equalization of the air pressure on both sides of the bearing will remove any possibility of loss of grease in this manner.

Fatigue

The operating limit beyond which ball and roller bearing fatigue failures normally occur dictates the load-capacity and life values in the bearing catalogs. Repeated stress cycles in heavily loaded contacts between the rolling elements and raceways of the rings eventually result in microscopic fatigue cracks at the weakest points in the grain structure of the bearing metal. With propagation of these cracks, small surface areas are loosened from the main body of bearing material. An initial fatigue pit formed in this manner is shown in Fig. 11. Once such a pit is formed, it becomes the center of very high stress concentrations which result in rapid extension of the fatigued area. Damage is then extended to other portions of the bearing by loosened

Fig. 11 — Progressive stages of fatigue flaking of inner raceways. SKF Industries. (Ref. 12)



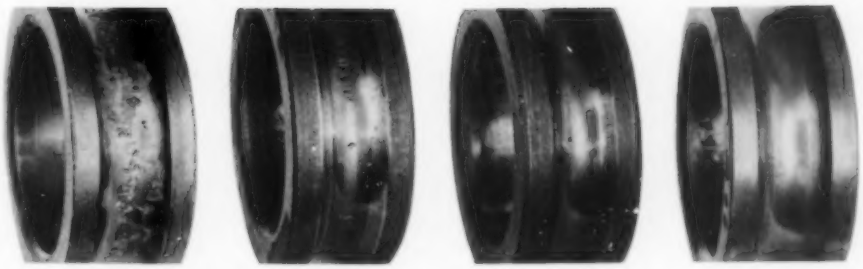
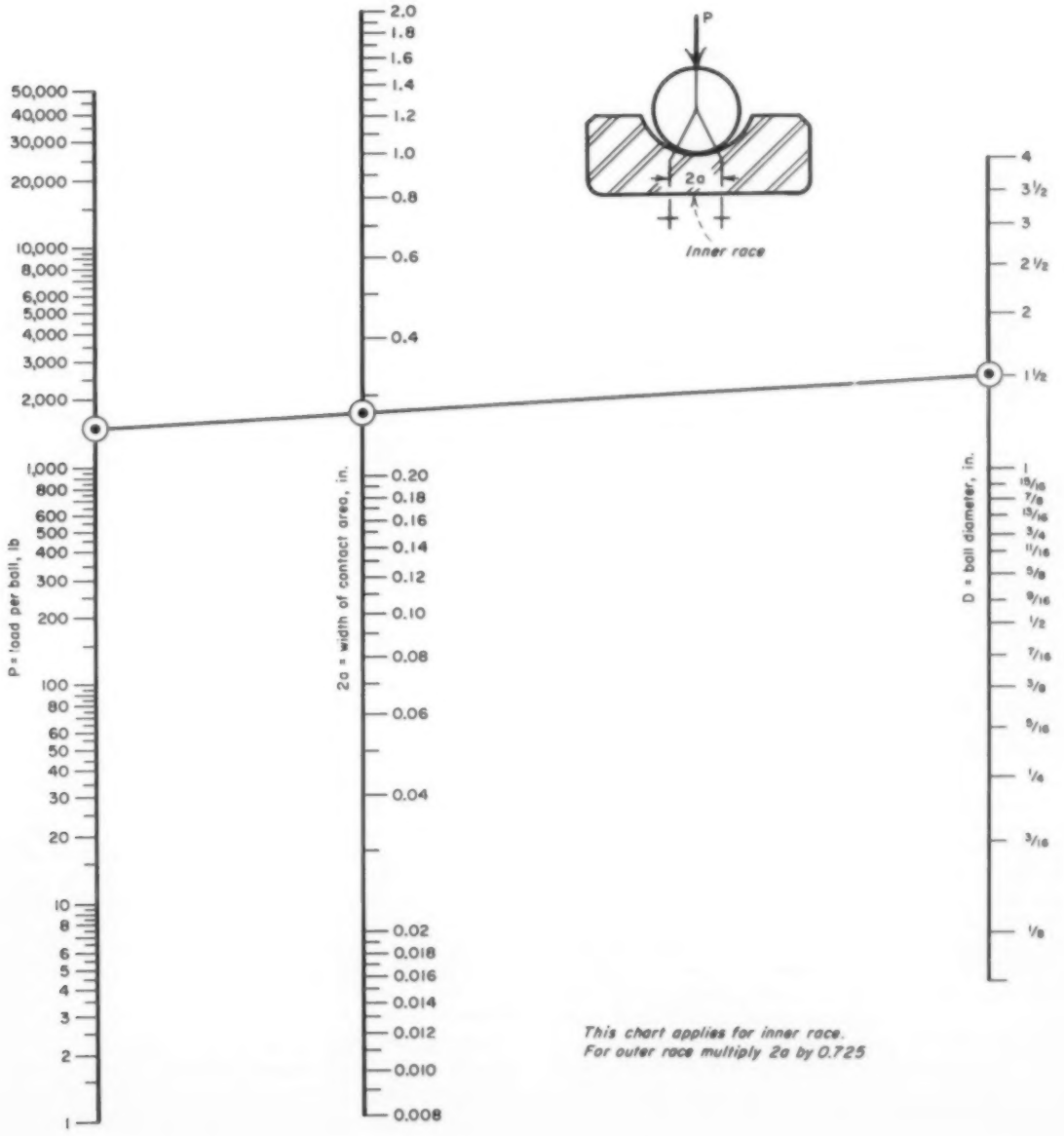


Fig. 10 – Progressive stages of flaking produced under conditions of sparse lubrication. SKF Industries. (Ref. 12)

Fig. 12 – Chart for estimating ball and bearing loads from ball track dimensions. The ball contact area, sometimes erroneously considered a point, is actually a long narrow ellipse, the major axis of which is exactly equal to the width of the ball path. Actual load per ball may be found in this nomogram and when load is multiplied by number of balls in bearing and divided by 4.25 will give radial load supported by bearing. For total thrust load find load per ball, multiply by number of balls, and multiply result by the sine of the contact angle. Minor bearing variations will make ball path appear wider than it actually is and load calculated will be higher than actual load carried. Marlin-Rockwell Corp. (Ref. 4)



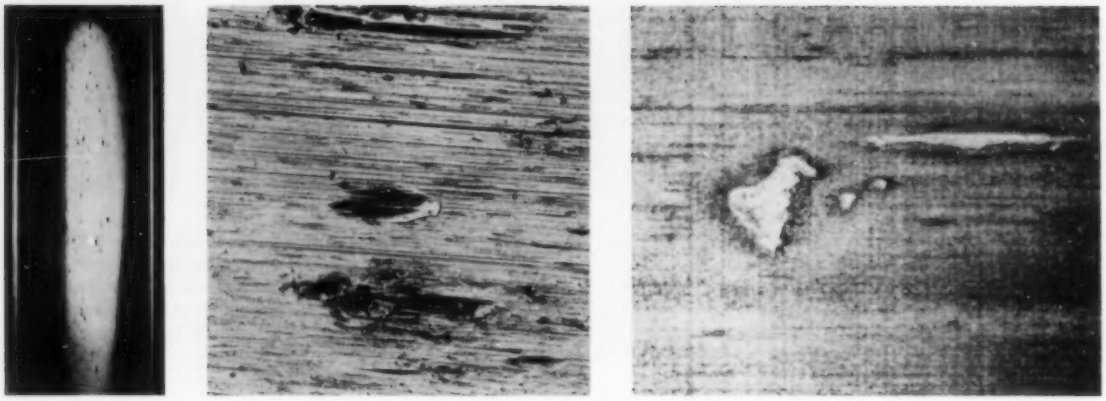


Fig. 13 — (A) Indentations in raceway caused by hard brittle particles. (B) Enlarged view of hard particle indentation. (C) Indentations in raceway caused by soft particles. SKF Industries. (Ref. 12)

flakes of metal and complete surface failure will finally result.

In cases of fatigue, a check should be made on the loads being carried by the bearing and the suitability of the bearing in question for such conditions. A check of the related machinery such as gears should also be made to determine whether or not loads are higher than those originally estimated in making bearing selection. Other factors such as misalignment, internal preloading or vibration may have been the underlying cause of high load. Actual bearing load may often be estimated by checking the dimensions of the ball wear track and applying the nomograph of Fig. 12 which computes load on the basis of ball deflection.

Dirt

Fully 90 per cent of the difficulties with early ball and roller bearings are due to dirt. The dirt may be introduced through improper care and handling of the bearing itself, from dirty equipment, dirty lubricants or dirty surroundings.

Presence of dirt in the bearing usually shows up as dents, scratches, or wear of the cage and bearing surfaces. Although a visual observation of the damage is often adequate, magnification of the area by 20 to 100 times with a glass or microscope is frequently useful in differentiating the damage by dirt from that caused by the passage of electric current, corrosion, or fatigue. With electric currents, the pits resulting will frequently be quite regular and microscopically will appear as small craters. Usually these craters will give a frosted appearance to the bearing surfaces. With corrosion, the markings will almost always exist on other surfaces of the bearing as well as in the path of the rolling elements.

Indentations of a raceway caused by hard brittle particles are shown at (A) in Fig. 13. When more highly magnified, as in (B), it will be seen that the raised edges of the indentations are being worn by subsequent running of the bearing. In (C) of Fig. 13, indentations in a raceway caused by soft particles, are shown. Brass, aluminum or even wood or paper can indent a rolling surface. Fine particles of abrasive dirt will gradually wear the rolling elements, cage, and raceway surfaces.

Corrosion

Moisture, sulphur and chlorine gases in the atmosphere, and corrosive lubricants all will attack rolling element bearings if they are not made of special material such as stainless steel. When corrosion spots are worn away during bearing operation, the resulting roughened surface will be subject to early fatigue at the points of stress concentrations.

Precautions used in handling bearings should minimize any possibility for causing corrosion before a bearing is in operation in a machine. In operation, the bearing can best be protected from rust by keeping it coated with an oil which is free of water and acids, or by a grease which will keep away moisture. Soda-base greases have been particularly effective in preventing rust by taking up small amounts of moisture in a bearing. These greases also function as rust inhibitors if dissolved in a larger quantity of water. Water resistant greases containing lithium soaps and various inorganic thickeners have also proved adequate in rust preventing characteristics for many applications; and when they have been inadequate in difficult situations such as are sometimes encountered in food canning, in exposed outdoor applications and in some types of railroad service, rust inhibitors in the greases have helped.

The rust spots on the end of a roller which was coated by a lubricant contaminated with moisture are shown in (A) of Fig. 14. The pitted surface resulting from the operation of a corroded roller is indicated in (B). Since small pits frequently form at the points of corrosion, it is sometimes difficult to differentiate corrosion from the effects caused by the passage of electric currents. In general, however, the evidence of corrosion will extend to other areas of the bearing than simply in the path of the rolling elements on the raceways. Under a microscope electrical pits will also show up as small craters, while corrosion pits will usually have a more irregular appearance.

Electric Current

When there is either an a-c or d-c voltage difference of 0.5 to 1.0 volt or more between a shaft and a bearing housing, electrical wear of the bearing surfaces is likely to occur. At such voltages, current will pass through the very thin

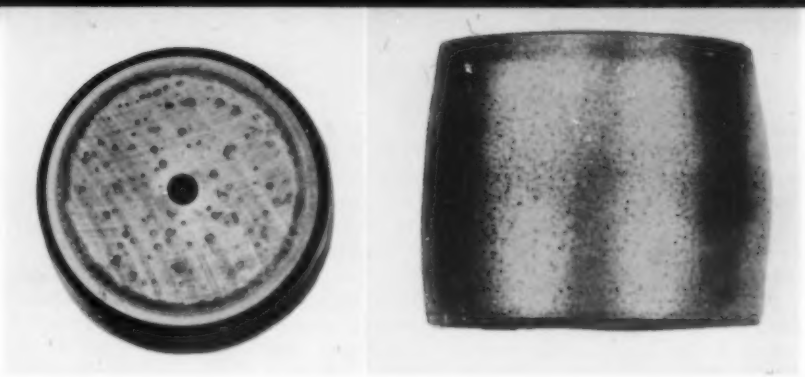


Fig. 14 – (A) Rust spots on end of roller caused by moisture in lubricant. (B) Corrosion caused by acids in lubricants with some moisture present. SKF Industries. (Ref. 12)

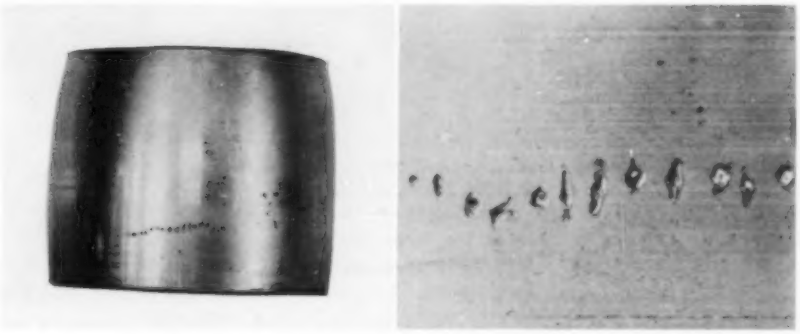


Fig. 15 – (A) Electric pitting of spherical roller caused by passage of relatively large current. (B) Enlarged view of electrical pitting on spherical outer raceway caused by relatively large current. SKF Industries. (Ref. 12)

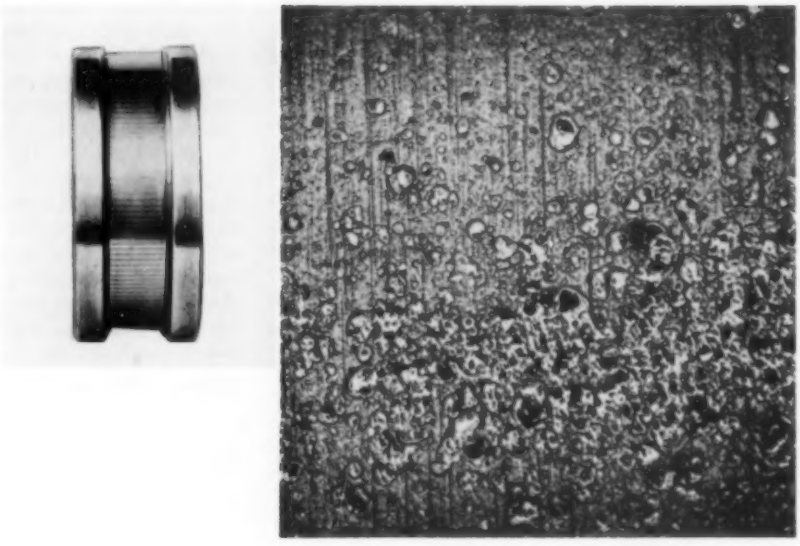


Fig. 16 – (A) Fluting on inner raceway of cylindrical roller bearing caused by prolonged passage of relatively small current in presence of vibration. (B) Enlarged view of fluted area of (A). SKF Industries. (Ref. 12)

film of lubricant between the loaded rolling elements and the raceways of the bearing. With the continual moving of the bearing elements, the passage of the current is interrupted with the generation of sparks and arcing. This causes melting at microscopic points of high temperature and small pits are generated in the metal. This type of bearing difficulty is rather frequently encountered in electrical equipment where stray electrical currents or unbalanced circuits may result in a rotor of the machine running at a different electrical potential than the stator. Difficulties may also show up in high speed mechanical units in which a static charge is built up on the rotor.

When a sudden surge of several hundred amperes passes through the axle or motor bearings of a railway car or locomotive, a series of relatively large pits are encountered as are indicated in Fig. 15. Although these pits are sometimes the centers for the formation of fatigue cracks, the particular bearing in the illustration was returned to service and ran for something like a million and a half miles more before being retired from service unfailed.

Continuous passage of small electric currents ranging in magnitude down to a few milliamperes results in a multitude of small electrical craters over the bearing surface. Initially, these pits give a frosted appearance, and this

appearance will become quite pronounced within even a few hours of operation with a small current flow. In a longer period of time, this frosting gradually reverts to a fluted "washboard" appearance. This peculiar surface breakdown has been observed in all types of ball and roller bearings. As the washboard surface becomes more pronounced noise and vibration increase.

The washboard surface on the inner raceway of a cylindrical roller bearing resulting from the passage of electric current is indicated in (A) of Fig. 16. An enlarged view of such a fluted area is indicated in (B).

A remedy is possible only by removing the voltage drop across the bearings. This can be accomplished either by insulating the bearing housing or by grounding the shaft through brushes.

Brinelling

True brinelling is permanent deformation caused by excessive loading of a bearing while it is not rotating. Either a heavy static load or a severe shock load can cause such dents in the raceways and rolling elements. Improper handling, pounding, and force on the outer ring during mounting of a bearing on a shaft are frequent causes.

False brinelling is a wear phenomenon. The appearance of the area damaged by wear is very similar to the permanent plastic indentations of a brinelled surface; hence the name. It usually occurs in non-rotating bearings when subjected to vibration or in bearings that are subjected to oscillations over a few degrees of arc. False brinelling is frequently encountered with bearings in equipment being shipped by railroad where it is subjected to vibration. Removing the weight of automobiles from the wheel bearings, and blocking the armature of a heavy motor or generator so as to remove its weight from the bearings has helped minimize such an effect. False brinelling such as that shown in Fig. 17 can occur on the raceways and rollers of a cylindrical roller bearing on a motor generator set standing idle on a vibrating platform.

Although the only positive means for control of false brinelling at the present time is to eliminate the oscillating and vibrating metallic contacts, the extent of the breakdown can sometimes be minimized by use of a soft bleeding type of grease or a plentiful oil lubrication supply with a low viscosity lubricant. Such lubricants will feed into the contact area to minimize destructive welding and tearing which would otherwise occur on the microscopic high points of the bearing metals coming in contact.

Excessive Preloading

Preloading exists when a bearing is loaded without the application of an external force. It is used to provide a more exact location and a more rigid mounting for a rotor than would be afforded by normal bearings. Preloaded bearings may be obtained as:

(1) Single bearings of "negative clearance". Such bearings are assembled with balls of larger diameter than the concentric space between the inner and outer ring.

(2) Duplex pairs so ground that when mounted, the bearings are loaded against each other.

(3) Tapered bore bearings.

Excessive preloading is an extension of preloading to the point at which the bearings become overloaded. This may be brought about by:

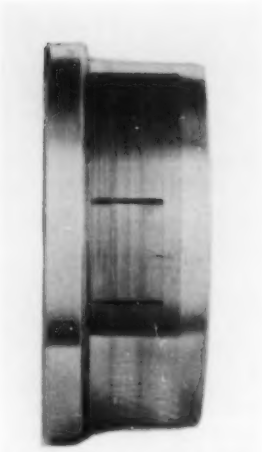


Fig. 17 – False brinelling on inner raceway of cylindrical roller bearing caused by small oscillatory motion while under load. SKF Industries (Ref. 12)

(1) Differential thermal expansion.

(2) Unequal axial spacing between the inner rings and outer rings.

Failure from excessive preloading may show up in two ways. If the bearing temperature reaches equilibrium without jamming or softening of the steel parts, an early fatigue failure will occur. If equilibrium is not reached and the temperature becomes excessive, the failure will have the same appearance as that in a lubrication failure. Preloaded bearings will normally run hot and are very susceptible to damage by dirt. Their lubrication is generally more critical than those of normal bearings. Because small changes in bearing operating conditions or in dimensions of machine elements can change normal preloading to excessive preloading, it is usually desirable to avoid use of preloaded bearings except where they are absolutely necessary. When they are used, every effort should be made to minimize effects of thermal expansion, to keep out dirt, and to supply a large quantity of cooling lubricating oil.

Improper Mounting

Improper shaft and housing fits will lead to bearing troubles. When the inner ring of a bearing rotates with the shaft and the outer ring is stationary, as is customarily the case, the inner ring of the bearing is usually pressed or shrunk on the shaft. The interference fit between shaft and ring should be sufficient to prevent slipping of the inside diameter of the bearing on the shaft, and yet not be so tight as to remove the internal play of the bearing and cause excessive preloading. If a very heavy press fit is used, there is danger of even cracking the inner rings as shown in (A) of Fig. 18. The other extreme is illustrated in (B), where the bore of the bearing is worn and scored because of too loose a fit and consequent turning of the shaft within the inner ring.

Much the same considerations are involved in selecting the fit for the outer ring in the bearing housing. A slip fit should be employed on the outer ring of at least one bearing in a machine using two ball bearings to avoid axial preloading of the bearings against each other during differential thermal expansion of the parts of the machine.

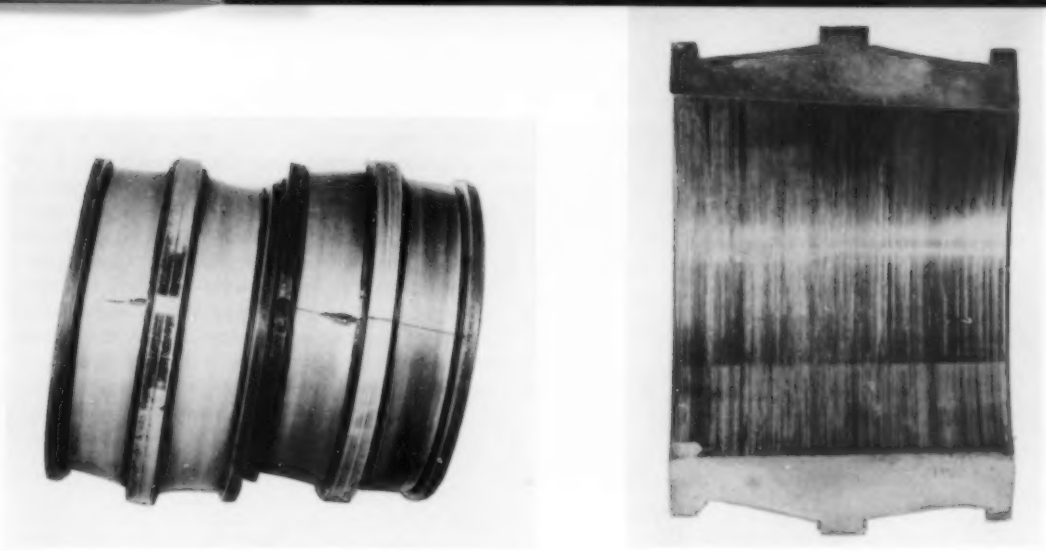


Fig. 18 – (A) Axial cracks caused by too tight a fit on shaft. (B) Wear of bore caused by too loose a fit on a shaft. SKF Industries (Ref. 12)

External surfaces of outer rings of bearings can be badly fretted by turning in the housing, as illustrated in Fig. 19. Wear and fretting will usually result in iron oxide wear debris collecting in the grease and causing difficulty. Vibration and improper contacting of the outer ring of the bearing with the supporting surface in the housing can be eliminated only by preventing the relative motion between the bearing ring and the housing through a press fit, an elastic mount as shown in Fig. 20, or rigid clamping.

Misalignment is another of the common bearing troubles associated with improper mounting. The more frequent causes of misalignment are tilted outer or inner rings, dirt which interferes with proper seating of the rings, a bent shaft, a misaligned housing, or a shaft deflecting under load. All of these result in a ball path which deviates from side to side in the raceway. Depending on the circumstances, a misaligned ball path may appear on either the inner or the outer raceway. With a misaligned inner ring, the misaligned ball path will appear on the inner ring of the ball bearing; while the ball path in the outer ring raceway will merely be wider than normal. The load is most severe at the point where the ball path approaches the edge of the groove and fatigue flaking would be expected there first. With a ball path deviating from side to side in the raceway, there also is a continual change in the ball speed which results in abnormal stresses on the cage and may cause it to crack or break.

High Temperature

Bearings operating at high temperatures will deteriorate in a number of ways. Separators will often be badly oxi-

Fig. 19 – Fretting on outside diameter of outer ring caused by non-uniform seat in housing. SKF Industries. (Ref. 12)

Fig. 20 – Anti-rotation devices for mounting bearing outer rings.

dized, balls and rings will be softened, and oil or grease used to lubricate the bearing will become dry, black and rancid from oxidation. High temperature often results from one of the types of failures discussed previously. Friction goes up, and with increased friction higher bearing temperature. A loss of adequate flow of cooling oil in a hot machine will also result in high bearing temperatures.

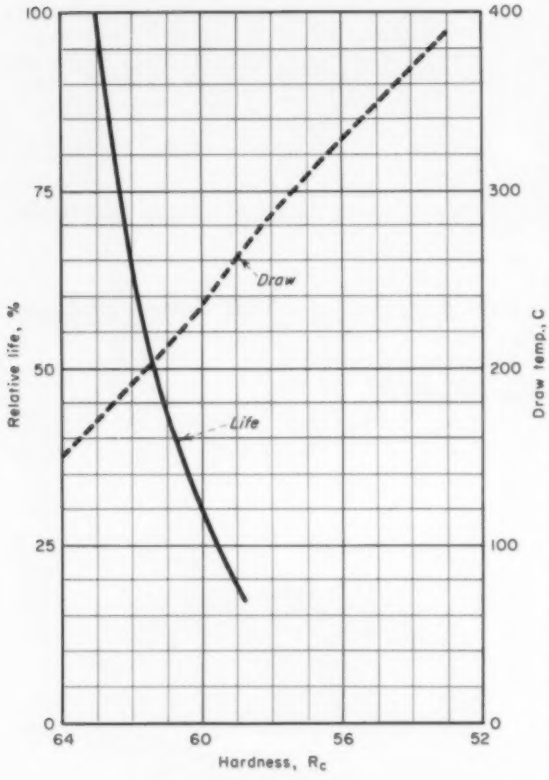


Fig. 21 — Effect of hardness of 52100 bearing steel on fatigue life.

Fig. 22 — Effect of heat on bearing balls. Marlin-Rockwell Corp. (Ref. 4)

Maximum temperature for a conventional ball or roller bearing constructed of the usual 52100 steel is 250 F. At higher temperatures this steel will soften with growth of balls and rings and loss of hardness. Under many conditions of bearing operation, deterioration in the properties of the bearing steel will result in an early fatigue failure or failure from loss of proper internal clearance. If a bearing is suspected to have failed because of high temperatures, the hardness of the steel of the rings should be checked. Reference to Fig. 21 may then give some indication of the operating temperature to which the bearing was subjected. An extreme effect of high temperature on bearing balls is shown in Fig. 22.

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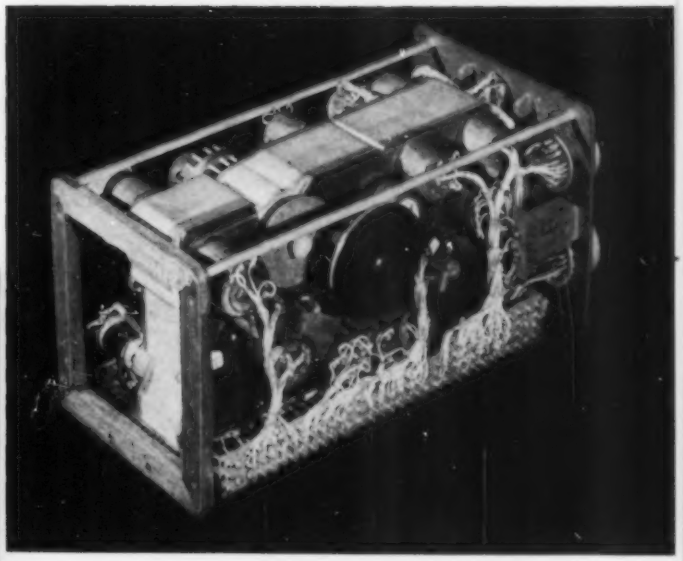


Fig. 1—Two examples of typical design mock-ups. Majority of components and structural parts are made of wood. Hardware, terminal boards and wire are the same as planned for final design. Left: an airborne antenna. Above: an electromechanical computer with wooden gears, synchros and servomotors.

Use of MOCK-UPS in design

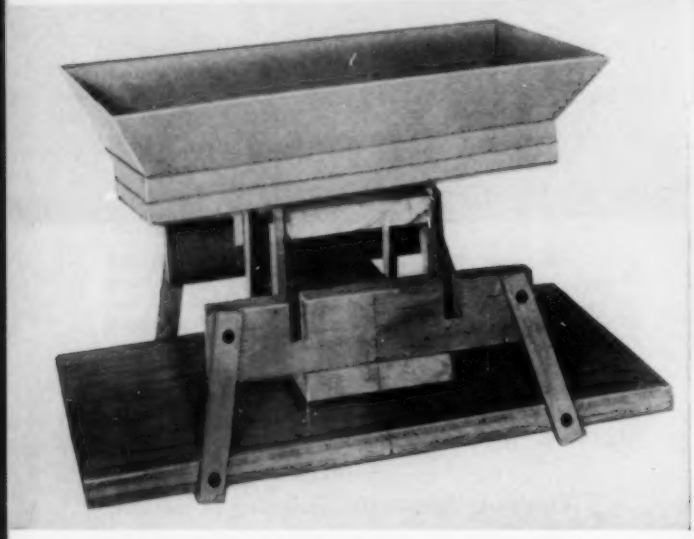
Compact, lightweight designing of intricate electronic and mechanical equipment can be greatly aided by use of appropriate mock-ups. Full scale models, made of wood for ease of fabrication, find application as preliminary design aids, as checks on accuracy of detail parts and an excellent means for developing wiring and cable harnesses. In addition, mechanisms having motion with several degrees of freedom, such as antennas and linkage computers, can have their operations and critical clearances checked.

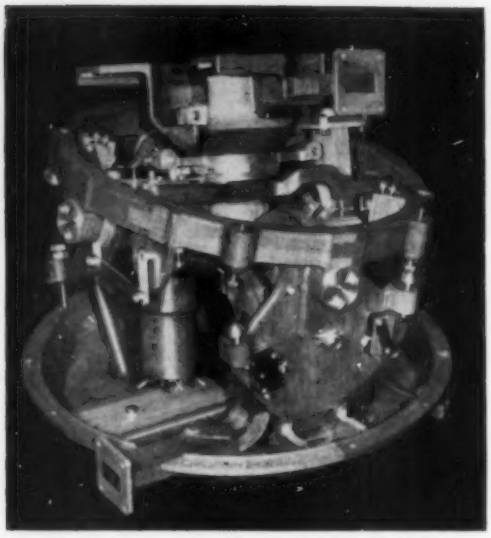
PHYSICAL DESIGN OF A NEW PRODUCT, regardless of its nature (mechanical, electronic, hydraulic, etc.) requires considerable forethought, imagination and a firm concept of progressive development of the creation. It is customary practice to execute this process in the form of a design layout and the usual detail drawings, plus various types of supporting drawings such as: pictorials, isometrics and artistic sketches. Although this procedure has been satisfactorily used in the development of many products in the past, current new design demands can be markedly improved and assisted with the use of carefully chosen design mock-ups. A typical example of a mock-up of an airborne computer is shown in Fig. 1.

Philosophy of Mock-Ups

General philosophy behind the use of design mock-ups is to present a physical replica of a new design in contrast to two dimensional drawings. A three dimensional model is a more comprehensive manner of describ-

Fig. 2—Motion study and elimination of interferences can be aided by use of simple wood pieces like those shown in the linkag antenna (below) or with more elaborate models like the two stabilized antennas. The stabilized antenna (right below) has three degrees of freedom, swings on metal bearings and has many of its other more critical parts made of metal. The stabilized antenna (right) has five degrees of freedom.





ing a complex unit. This is particularly true if the people for whom it is intended are not versed in the reading of drawings and layouts.

As a rule, although not necessarily so, the mock-up is full scale and duplicates the actual design in all critical matters. For ease of fabrication, wood is usually the basic material. However, better performance and versatility can be obtained by prudent choice of materials such as shafting, sheet metal and plastics.

The stage of design development where mock-ups are most valuable is not a rigid matter. Their usefulness extends throughout design and fabrication. At the early design stage of preliminary layout a complex product may have several alternate solutions. Rough models from the layout drawings permit a comparative evaluation. This is particularly helpful in that at this preliminary stage many non-technical persons, such as company executives, sales managers, contract managers, and the customer's representatives, wish to participate in the discussion and shaping of plans. From the viewpoint of the design work, this is the best time for evaluation, criticism, and changes. To obtain the maximum aid from this reviewing group, it is necessary to assist their comprehension as much as possible.

When final layout is completed a more finished appearing model can be constructed. More effort and expense may be put into this model since it is the result of previous design conferences and reviews and, therefore, should reflect more accurately the desired design. The value in its construction appears in the solution of questionable and difficult to visualize finer details including internal structure.

Final stage of mock-up building is at completion of the layout and details. Fabrication of a model at this time shows further details of the design and also proves the accuracy of detail drawings. This model is the most complete and accurate and is as far as it is necessary to go except for resulting corrections, improvements and changes found through its construction.

It should be realized that a series of mock-ups need not be made for the three stages mentioned. Depending upon the desired purpose of the mock-up and the complexity of the unit to be designed, one or more models can be made. On some occasions only a preliminary rough model is required; on other occasions only a final mock-up is constructed.

Several alternatives are possible in the preparation of drawings and general information for construction of a

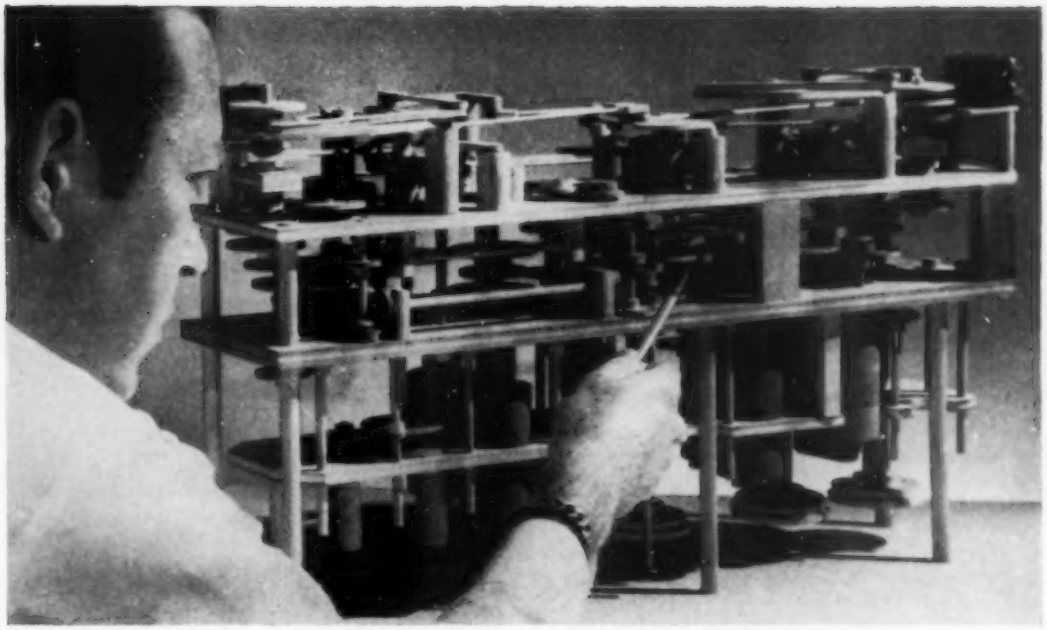


Fig. 3—A complex mechanical linkage computer. Note wooden bevel gears (nonworking), cams, shafts and linkage interrelationships which would be difficult to visualize from layout drawings.

mock-up detail and assembly drawings. These would spell out substitute materials (for the metal parts) and fabrication simplifications as compared to the design of the real details. The alternate procedure stems from a desire to save time and drafting cost. The layout drawing is used as the basis for fabrication and is the sole source of information to the model maker. This can be conveniently done if the layout is complete, clear and specially marked with pertinent information for the mock-up.

The latter procedure is favored in that it allows slightly earlier construction, since time for detailing is eliminated. This is an advantage in that the utility of having a model increases as it predates final designing.

Benefits and Applications

Full value of mock-ups is not readily appreciated from a superficial coverage of the subject; following is a list of specific benefits:

Aid to Visualization. One major purpose of a mock-up is to present the new design in the most easily comprehended manner. It is an excellent means for conveying design proposals to non-technical people, who usually have difficulty in visualizing a three dimensional unit from a two dimensional drawing. Mock-ups are also of considerable value at conferences and demonstrations.

Comparative Evaluations. Allied to the previous benefit is the parallel one that a set of mock-ups representing various design alternatives lend themselves to a convenient means of comparison and evaluation.

Sales Show Piece. A further related value is that an attractive mock-up is a valuable advertisement and the sales department can make excellent use of it in this manner.

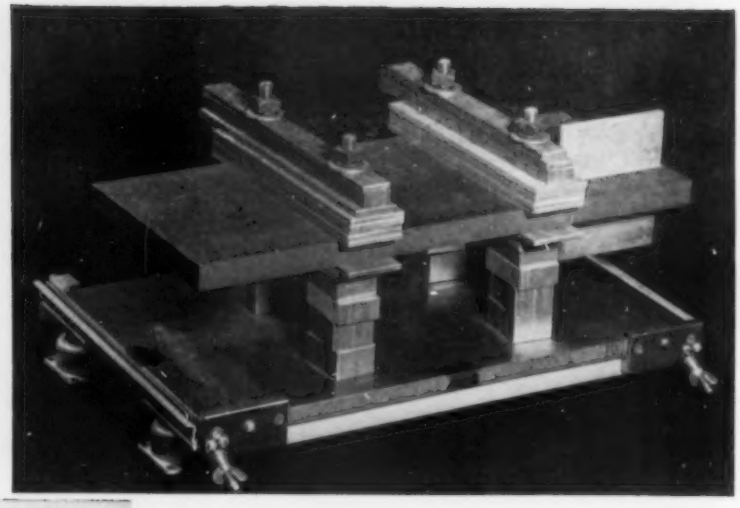
Design Aid. Not to be discounted is the value afforded to the design engineers and draftsmen in having a model to work around. Skilled as these people are in visualization, a mock-up crutch can be of great value.

Interference Study. Making a mock-up aids in the discovery of interferences, particularly where moving parts are involved such as stabilized antennas, linkage computers, etc. When it is known that a mock-up will be made, the design allowance on critical clearances can be intentionally decreased since there will be an opportunity to make a careful check of this. A mock-up design plan then results in more compact designing, still free of interference.

Moving antennas are excellent examples of applications in which mock-ups are indispensible. Three axis motion is difficult and tedious to check out on a layout. With a mock-up, hours of investigation on paper can be condensed to minutes. Fig. 2 shows examples of antenna mechanism mock-ups having several degrees of freedom.

Linkage computers are another example of mechanisms with complicated motion which can be conveniently studied in mock-up form. Fig. 3 is a typical example.

General Check of Detail Drawings. A mock-up phase, particularly near the end of design and drafting allows for a general check of design and drawing details. Design oversights are discovered, omitted details found, and dimensional errors and omissions disclosed. It is particularly helpful to have such errors discovered during the fabrication of the less critical mock-up. To have the same mistakes discovered in the fabrication of the first real



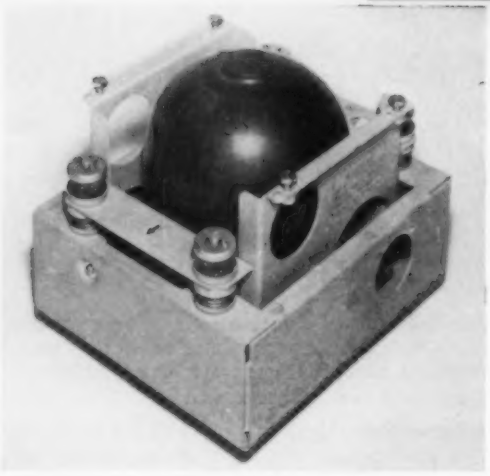


Fig. 4—Two examples of mock-ups used for shock and vibration study. Right: a crude model duplicating only weight and center of gravity with bolted masses of metal. Below: a similar crude model but with more realistic external mounting features.

unit would result in expense and loss of time.

Wiring Information. Perhaps one of the most valuable contributions is the assist mock-ups give in determining wiring of electrical and electro-mechanical units.

It is difficult to plan cable routes, cable shape, clamp locations wire lengths, optimum location of terminal boards, and optimum terminal tie points. When a mock-up is contemplated, nothing more than a rough plan need be executed until completion of the mock-up. When the model is turned over to a skilled wireman along with an electrical schematic and the wiring details are left for him, along with the supervising engineer, to determine empirically. This has the distinct advantage of removing the wiring task from the package designer and placing this task with a skilled expert who best knows the various design parameters from firsthand experience.

This is a fundamentally good approach because few if any designers have love or skill for wiring plans and layouts. The result is that the mock-up serves the purpose of solving essentially all wiring questions and allows for complete specification of information for the manufacture of the first real unit. This facility of the mock-up can be appreciated from careful observation of the units shown in the illustrations. Contrast this with the usual practice of determining these details on the first unit. Time-saving alone may make the mock-up financially worthwhile.

Wired mock-ups offer the added advantage of providing information for prefabrication of wire lengths and cable harnesses for the first real model. This will result in a very substantial saving of time in wiring the first unit.

Reduced Handling and Damage to Real Unit. A further unique benefit in solving wiring problems on the mock-up is the freedom from damaging a valuable unit. Work-out of a wiring plan on the bench involves much handling, particularly since portions of the job are often redone several times. Exposure of components to experimental wiring and re-soldering is risky, especially if there are closely associated mechanical assemblies such as gear trains. Extensive re-soldering frays and damages conductors and insulation. Therefore, if experimental wiring and development is done on a mock-up, the first real unit will not be subject to danger of either serious accidental damage or appearance deterioration. The actual unit and its valuable components are only wired once in accordance with the final plan worked out on the mock-up.

For example, an illustration at the end of this article shows a mock-up of approximately $9,000 of electrical components, exclusive of precision gearing, and its wiring is very complex. Imagine the freedom from fear provided the wireman in initially working with a wood dummy rather than the expensive real unit.

Inter-Unit Connection Cables. Interconnecting cables are a major problem in larger electrical systems composed of many separate units. With a set of mock-ups this can be investigated by arranging the units as per the intended installation and empirically experimenting with various cable schemes. For this application scaled down models $\frac{1}{2}$ or $\frac{1}{4}$ scale, are convenient. They also result in a portable system display.

Inter-Department and Company Educator. Another safe-guard provided by a mock-up is its use throughout

different departments in a company for various study reasons, without concern about serious damage occurring in extensive and rough handling.

On one occasion this proved helpful when there was need for sending a development mock-up from the east coast to the production site on the west coast for study. Had there been no mock-up, the production people would have been deprived of valuable assistance since the real development unit could not be spared for loan to a distant plant.

First Production Guide. An important benefit to production is to have a mock-up available for guiding first unit assembly and wiring. True, this same information is carried on drawings, but no written description can be as informative, vivid and simple as a three dimensional model.

Cost Estimating. The mock-up can be used for rough cost estimating early in the design. Later, when all drawings are complete, it is still helpful in that the cost estimator can refer to it for a quick comprehension of the entire unit, subassemblies, complexity and details.

Assembly Check-Out. A mock-up is used in early, design stages for checking interrelationships of intricate subassemblies and examining for adequacy of mounting. Occasions have arisen when the ability to accomplish assembly of complicated mechanical subassemblies may be uncertain from the layout. The question is easily settled by building a mock-up of the parts involved.

Weight, Center of Gravity and Moment of Inertia Determination. Complicated and irregular but homogeneous parts, such as castings, can have their weight, center of gravity and moment of inertia determined by means of mock-up parts. This is accomplished by performing the measurement on the mock-up and converting the answer by proper ratio of densities for real part material and mock-up material. This is of particular value in early design stages when these values are required for calculations necessary to verify or extend the design.

Balance Determination. Mechanical units involving rotating or sliding parts can be checked for balance by means of the mock-up. If proper bearings or friction surfaces are used, accurate measurements can be made and need merely be altered in accordance with the density of materials to obtain answers for the real unit.

Vibration and Shock Tests. A special use of mock-ups is for the purpose of evaluating vibration and shock mounts. A dummy model is fabricated from wood and metal to simulate the mass and center of gravity of the real unit. It is fastened to a real mount and the entire assembly subjected to vibration and shock tests for performance evaluation. This offers the opportunity of designing and testing a mount well ahead of the fabrication of the real unit. Also, using a mock-up removes the risk of damaging the real unit if the mount is inadequate.

A mock-up for this purpose need not be an accurate replica or an attractive unit. It is important only to duplicate mass and center of gravity. This can be done inexpensively yet accurately as shown at right in Fig. 4. However, sometimes the mock-up is also used for vibration clearance studies and as a show piece. In that case an accurate unit is made and lead or brass loads are concealed within the unit to provide correct mass and center of gravity. The gyro mock-up, shown below has an appropriate metallic core to enable its use for vibration tests.

Design and Fabrication

A mock-up is intended as a temporarily helpful item destined to lose its value when the real units are produced. This leads to the proper philosophy of designing and building the mock-up as economically as possible. The faster the mock-up can be fabricated the more it will contribute to the design.

Material. Although material used in the real unit is predominantly metal, the mock-up is best made from wood, which is easily worked and can be conveniently modified as design changes dictate. Woods used are generally mahogany or clear pine because of their softness and even texture. Small moving parts perform better when of a hardwood such as maple.

However, wood has limitations. Thin sections are fragile and in some places it is necessary to use reinforcements or make the part entirely from metal. When metals are specified, they should be easily worked types such as aluminum or brass. Moving parts, such as rotating shafts or links, when made of wood are usually not accurate enough and function poorly. It is better to substitute inexpensive sleeve bearings or ball bearings.

Cardboard is used in rough mock-up construction particularly for electronic units. It has high strength for its thin section, and is readily cut with scissors, making it a suitable preliminary material. Similar in form to sheet metal, it lends itself well to use in models of electronic chassis and associated sheet metal parts.

Simplification. Careful attention to simplification of mock-up fabrication can result in large cost reduction and time saving without sacrifice of utility. Sections that will be cast thin-walled and ribbed can be made solid and to the full thickness, which also results in a stronger mock-up. Volumes containing multitudes of small or intricate parts such as electronic chassis, gear housings, etc., can be left solid. Lightening holes can be omitted and indicated by a painted pattern.

Use of Standard Parts. To save fabrication cost and time, small complicated details which are relatively inexpensive, should be included as purchased parts. This would apply to knobs, latches, dial faces, terminals and boards, connectors, cable clamps, small resistors, etc. Examples of this can be found in the illustrations.

Wired Mock-Ups. To facilitate the wiring operation and its perfection, actual connectors and terminal boards should be used. Wire identical to that called for in the final unit must be employed to obtain an accurate duplication of the wiring problem.

Finish. This should be determined by the intended use of the mock-up. The more of a show piece the model is to be, the more effort must be applied to finishing. Range varies from bare natural wood to highly polished and painted models. One helpful practice is to color code

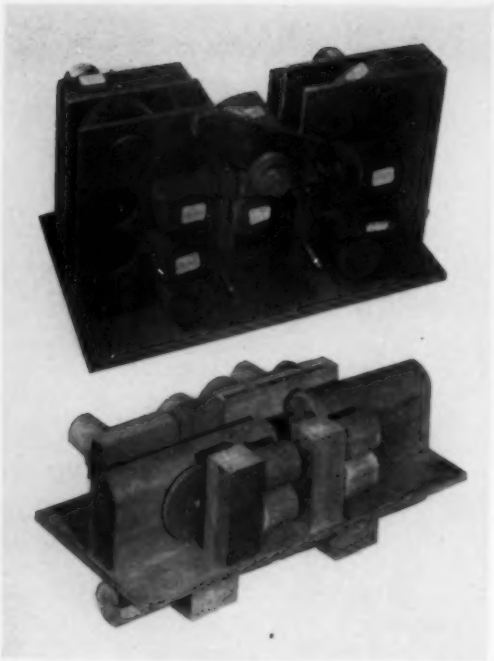


Fig. 5—Early design stage mock-ups of subassemblies of a complex electromechanical computer.

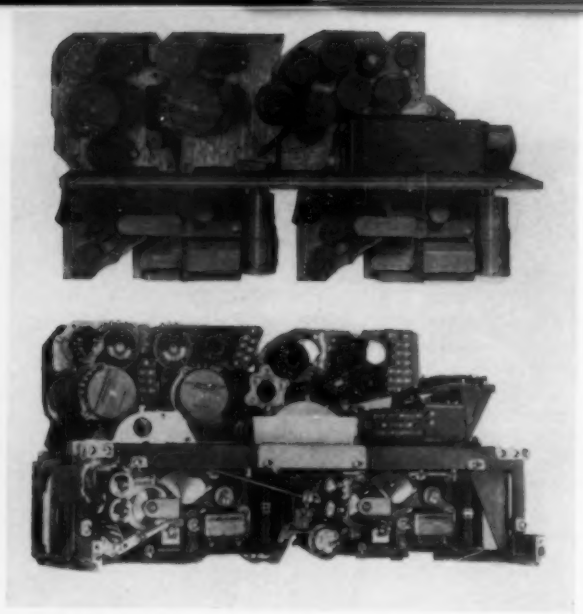


Fig. 6—Advanced design stage mock-up of computer subassembly compared to finished prototype. Note simplification of the mock-up to keep cost to a minimum without impairing its value.

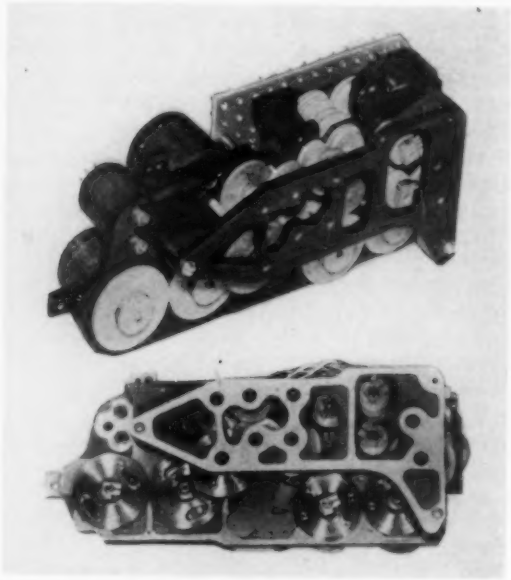


Fig. 7—Mock-up and real subassemblies showing detail parts. Structural parts are duplicated faithfully in the model, gears and bearings are simplified for economy.

parts. For example, in analog computer mock-ups servo motors are painted one color, synchros and other sensing elements another etc., all different from housings and miscellaneous parts.

Gears and other moving parts such as cams and links are often contrasted by choice of wood, usually using a hard type such as maple or birch. Thus, even if no final finish is added, there will be a natural color distinction. In the illustrations gears made of maple show lighter than the surrounding parts.

Sources

Mock-up fabrication is a new and limited field. Many concerns are making use of such design aids, but the extent is still small. There are few mock-up shops which can properly serve the needs of industry.

Wood pattern shops or industrial model houses have limitations. They are accustomed to working from detailed drawings rather than layouts. Pattern shops are almost strictly wood users which limits their ability to substitute metal and plastic where required. Also, neither shop is familiar with or capable of doing electrical wiring.

An additional limitation of outside shops in regard to military work stems from their lack of security clearance. Completed mock-ups are often classified. This requires special security clearance for outside vendors, who do not need it for their normal work, and it is a further obstacle and delay.

By far the best procedure is to have sufficient mock-up work to permit establishment of a facility within the company. Then it is possible to combine proper equipment, material and personnel so as to produce complete mock-ups. It also allows for a minimum preparation of drawing information, maximum use of layout type drawings, and quickest delivery.

Special mock-up facilities are possible only for larger companies which leaves smaller ones dependent upon outside vendors. However, there is one unique procedure which some small concerns have used. Design engineers

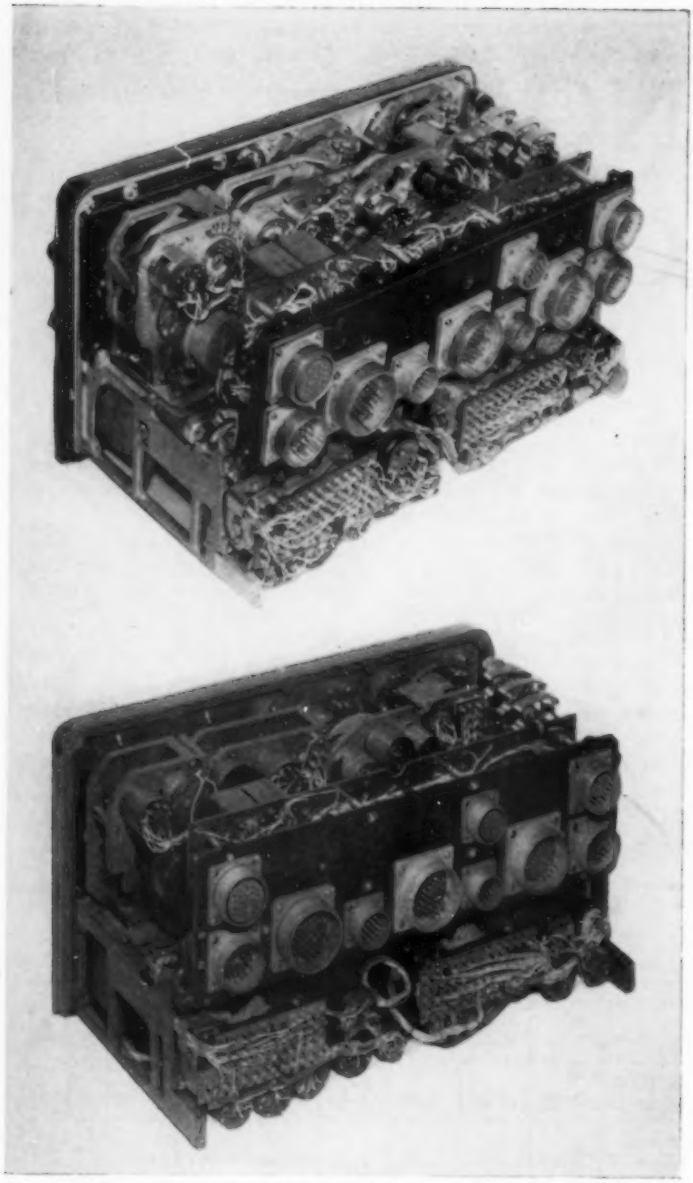


Fig. 8—Bird's-eye view of final design of the large mechanical computer whose subassemblies are shown in Figs. 5 through 7. Assembled and wired it is an accurate duplicate of the real prototype.

and draftsmen build the mock-up as a parallel operation to their normal work. This rather unorthodox procedure is by far the most economical and fastest since the drawing requirement is an absolute minimum. Further, much time is saved in that there is no liaison time loss. Of course special skill is required of the design engineer and few can qualify. This bottleneck on talent can be eased in overtime or outside work. Design engineers skilled in woodwork often have homework shops that can be helpful to the project.

Cost

Financial cost of a mock-up is directly related to complexity and desired workmanship. As a rule models will cost less than 1 per cent of engineering associated with the design. For example, the cost of the mock-up shown in Fig. 8, including running changes, was approximately $1000; development engineering cost $125,000; and production unit cost $25,000. In any event, experience has shown the cost is returned several times over in savings accomplished as cited in preceding paragraphs.

Sample Application

To further show the value and application of mock-ups, a brief review is made of an actual design case. Fig. 8 shows the main assembly of a large airborne computer box, with outer cover removed. Packaging complexity of mechanical and electrical components plus wiring is evident from the illustration. Design evolution of such a unit is a long hard task.

First mock-ups were of a preliminary nature made very early in the study layout phase. Two design approaches, which were modeled but abandoned, are shown in Fig. 5. Note crudeness of mock-ups and lack of similarity between them and the final unit shown in Fig. 6 and 8. As the design progressed, a more accurate mock-up was constructed, which is shown in Fig. 6. This unit shows considerable similarity to the final design which can be better appreciated by comparison to the real partial assembly shown in the same illustration. Still later, some subassemblies were detailed. Examples are shown in Fig. 7 where mock-up and real units are contrasted to show a high degree of identity.

Upon reaching this design stage, the mock-up was used as wiring and cable harness dummy. The completely wired mock-up is shown in Fig. 8. The degree of complexity of the wiring and the value in making a wired mock-up is clearly apparent. The mock-up was of additional value in that the photographs used for these illustrations were sent to a geographically remote manufacturing plant to be used as a prototype and illustrative example of the wiring of the first production units.

This mock-up was fabricated without preparation of any special mock-up drawings. Much of it was constructed from layout design drawings. Exceptions are some of the detailed subassemblies, such as those of Fig. 7, which were made from actual detail drawings.

CASTING DESIGN

Basic design considerations

Recommended drafting practices

BERNHARD ROGGE
Chief, Design Evaluation Unit, U. S. Army Chemical Corps.

SOUND CASTINGS—sand, permanent mold, die or plaster mold—free from such defects as shrinks, tears, cold shuts, misruns and hard spots call for specific design considerations on section thickness, ribs and flanges, fillets and corners, lugs and bosses. Consistent design practices require setting up standards for tolerances, machine finishes, identification marks and inspection notes.

SECTION THICKNESS–Sections should be of minimum thickness consistent with good foundry practice, yet providing adequate strength and stiffness. Suggested minimum thicknesses for various materials are given in Table I. The least expensive design is one which is as light as possible without incurring difficulties in molding. If the walls are too thin or if the molten metal must travel too far, the result is a "cold shut"–a seam giving a weak spot in the casting.

Where there is to be greater than 30 per cent difference in thickness of adjoining sections, gradual transition from one to the other is necessary to prevent severe internal stresses and cracking of the metal on cooling. Illustrations in Fig. 1 show good casting design practice.

RIBS AND FLANGES–Ribs are used principally as stiffeners and reinforcing members and are employed to minimize distortion in castings with large flat areas. Properly designed and correctly located ribs reduce overall weight and

Fig. 1–Good section design practice

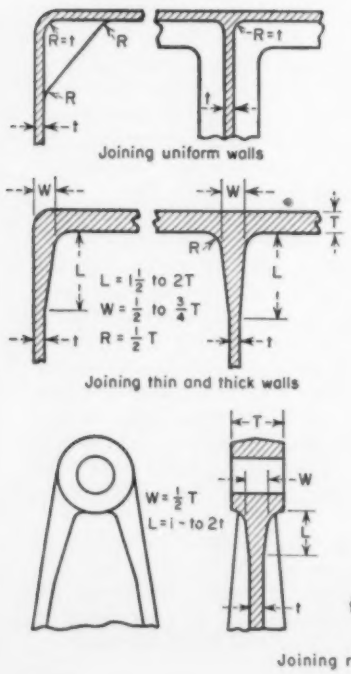


Table I—Minimum Recommended Section Thickness and Fillet Radii

Materials	Sand Casting		Permanent and Semi-Permanent Mold Casting		Die (Pressure Mold) Casting		Plaster Mold Casting	
	Sect. Thick.	Fillet Radii	Sect. Thick.	Fillet Radii	Sect. Thick.	Fillet Radii	Sect. Thick.	Fillet Radii
Magnesium Alloys	3/16	3/16	1/8	1/8	0.080	0.032	3/32	.....
Aluminum Alloys	3/16	5/32	5/32	1/8	0.080	0.032	3/32	.....
Steel	3/16	3/16	.....	.....	.....	.....	.....	.....
Brass and Bronze	3/32	5/32	.....	.....	0.080	0.032	3/32	0.032
Iron	5/32	5/32	.....	.....	.....	.....	.....	.....

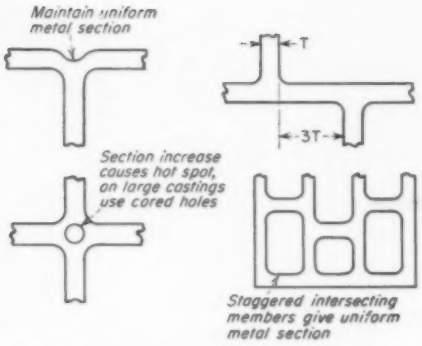

Maintain uniform metal section
T
3T
Section increase causes hot spot, on large castings use cored holes
Staggered intersecting members give uniform metal section

Fig. 2 – Good intersection of ribs.

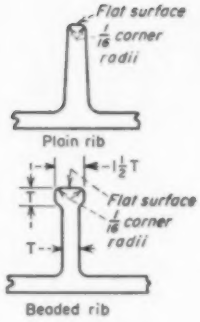


Fig. 3 – Details of good rib design.

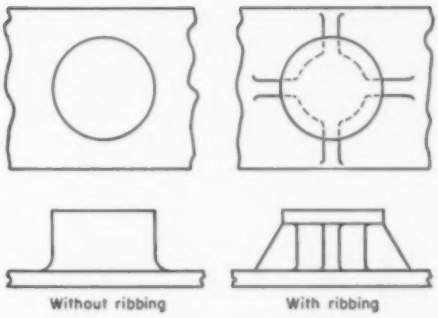


Fig. 4 – Boss, supporting-rib design.

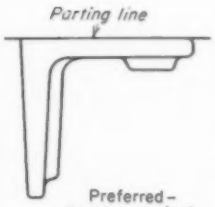
aid in attaining uniformity of section. When intersecting ribs or junctions of members may result in high concentration of metal and resulting hot spots, staggering of ribs is recommended; or, in the case of large castings, simple cores may be used at the intersections to equalize cross-section. Good design practice is shown in Fig. 2.

Ribs and flanges should have flat surfaces with small corner radii to eliminate high outer fiber stresses; and, as shown in Fig. 3, rib thickness should approach that of the section to which it is joined. Fig. 4 shows how a supporting rib construction can be used (right) to equalize thickness at a boss, in place of a heavy section (left).

FILLETS AND CORNERS–Adequate fillets at all intersections materially increase the strength and soundness of castings. Too large a fillet in a rib causes localized heavy sections and results in weakness. When the wall or web thicknesses are greater than the minimum values shown in Table I, fillet radius should be equal to wall thickness.

LUGS, CLEVISES, AND BOSSES–Special attention to the design of lugs, clevises, and bosses can reduce molding cost. Metal sections between lugs or bosses and the body of the casting should be uniform to insure proper flow of the molten metal. Wherever possible, bosses should be extended to the parting line to make molding easier and to reduce pattern cost. An example of boss design is given in Fig. 5. On large castings, bosses should be designed with uniform metal sections, as shown in Fig. 6, which results in sound castings, less weight and lower machining cost. When drilling holes in lugs or clevises, sufficient edge distance must be allowed for in the casting to provide for wider tolerances; also, the casting edge radius R in Fig. 7 should be $1\frac{1}{2}$ times the hole diameter plus 3/32 in.

POCKETS, RECESSES AND INTERNAL CORES–Coring adds cost to castings and requires wider tolerances in the design of a part. Whenever possible, cores should be



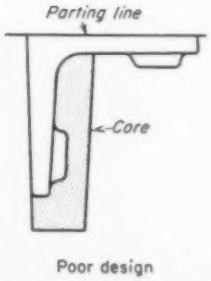


Fig. 5 – Boss design.

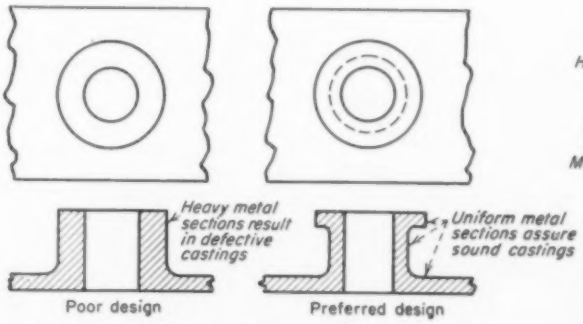

Heavy metal sections result in defective castings
Uniform metal sections assure sound castings
Poor design
Preferred design

Fig. 6 – Bosses on large castings.

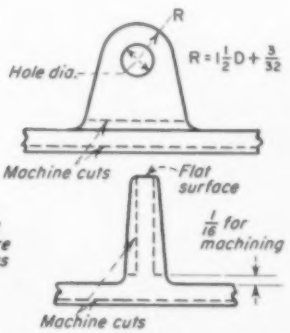


Fig. 7 – Lugs and clevises.

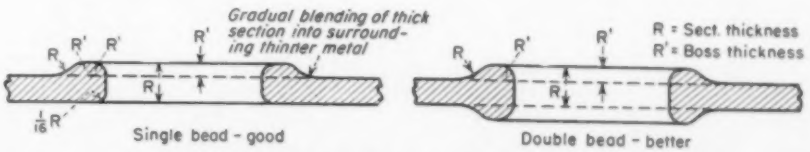

Gradual blending of thick section into surrounding thinner metal
R = Sect. thickness
R' = Boss thickness
1/16 R'
Single bead – good
Double bead – better

Fig. 8 – Beading of cored holes.

avoided, except in cases where such factors as weight, uniform thickness, and elimination of machining, make the use of cores more economical or give a structurally sounder casting. Cored holes should be beaded in their webs and walls whenever possible, as shown in Fig. 8, without causing additional core work. For internal cores, clean-cut holes of sufficient size must be provided to permit the easy removal of the core sand. Deep pockets and small recesses that complicate molding should be avoided. The minimum size for cored holes in small and medium size castings is $\frac{3}{8}$ in.; for large castings over 2 in. thick, 1 in. It is cheaper in many cases to drill small holes than to core. For die castings, the minimum size hole is 3/32 in. provided the length does not exceed three diameter; for holes $\frac{3}{16}$ to $\frac{1}{2}$ in. diameter, the length should not exceed six diameters, and over $\frac{1}{2}$ in., ten diameters. Holes smaller than $\frac{1}{4}$ in. diameter cannot be cored in permanent mold castings.

DRAFT—Draft allowance is necessary and must be considered in preparing drawings, Fig. 9. Draft angles for sand-mold castings should be 1 deg and for cores 2 deg plus or minus $\frac{1}{2}$ deg. For permanent mold castings, the standard draft is 2 deg, and for removable cores up to 5 deg. Draft for die castings is very important. The largest

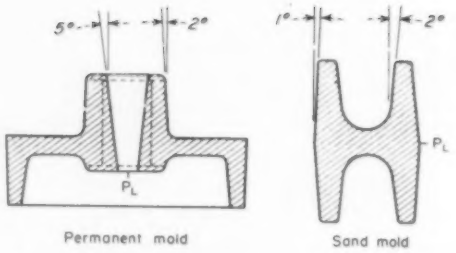
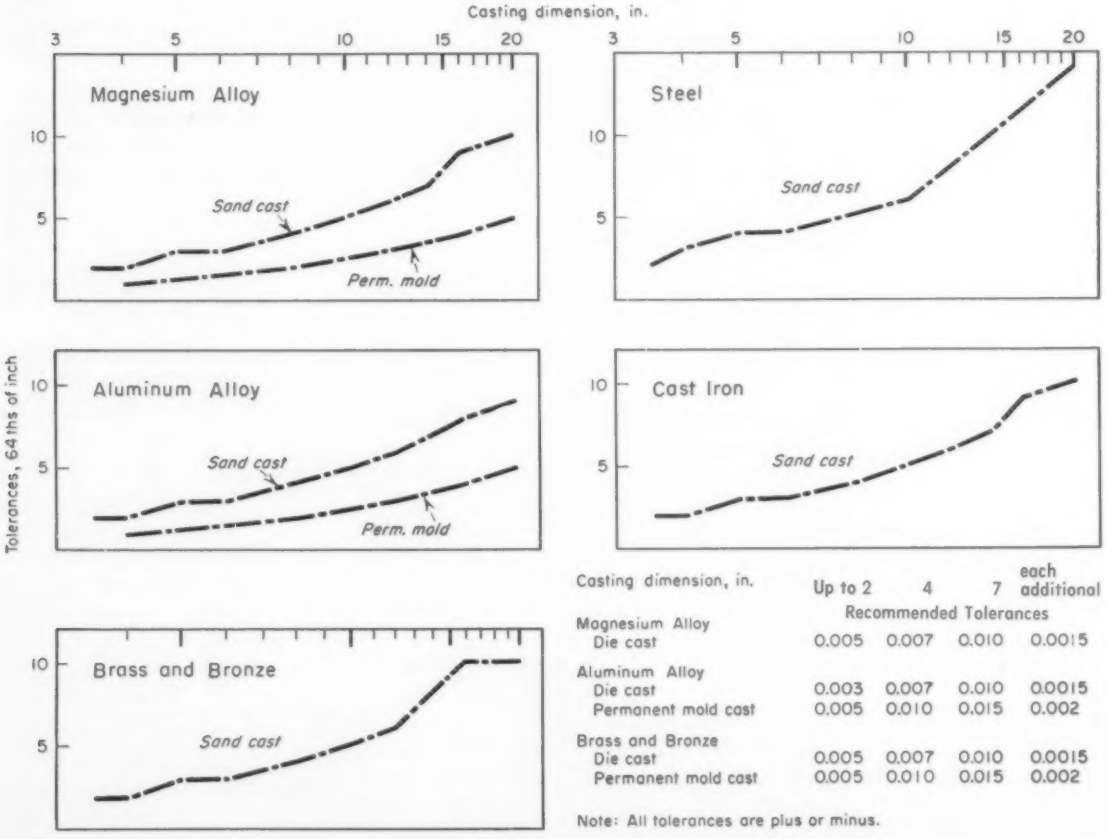


Fig. 9 – Draft allowance.

reasonable draft will result in faster production, smoother finish, and fewer rejects. For outside surfaces, a 1 deg draft is desirable, but where the shape of the part allows free shrinkage away from the die, draft may be reduced to as little as 0.005 in. per in. of height. Parts which tend to shrink onto the die may require up to 2 deg of draft, depending upon the depth and cross-section of the obstructing part of the die. For plaster mold casting, a 1 deg draft angle is desirable.

Draft helps in removing patterns from sand molds and generally to prevent mold wall spalling. Allowances shown here are minimum.

Table II—Recommended Casting Tolerances



Casting dimension, in.	Up to 2	4	7	each additional
	Recommended Tolerances			
Magnesium Alloy				
Die cast	0.005	0.007	0.010	0.0015
Aluminum Alloy				
Die cast	0.003	0.007	0.010	0.0015
Permanent mold cast	0.005	0.010	0.015	0.002
Brass and Bronze				
Die cast	0.005	0.007	0.010	0.0015
Permanent mold cast	0.005	0.010	0.015	0.002

Note: All tolerances are plus or minus.

Drawing Practice

TOLERANCES–Dimensional variations in casting are related to the size, material, shape and configuration of the part, and it is good design practice to allow for liberal tolerances for most economical production. As a general guide in designing and laying out a casting, the tolerances shown in Table II will apply.

MACHINE FINISH ALLOWANCE–The amount to be allowed for machining is generally left to the discretion of the shop, but the designer should not completely ignore this allowance, as it affects the general design and often the function of a part. It is advisable to show in phantom lines the approximate allowance for machining without dimensioning. Table III gives data to use as a guide in preparing drawings.

LOCATING POINTS–On complicated or intricate castings, locating and checking points should be established and indicated on the drawing so that castings can be checked from the same point by subsequent processors. Locating points should be placed on the same side of the parting line if possible, and the points should be as far apart as the size of the casting permits in order to insure most accurate results.

IDENTIFICATION MARKS ON CASTINGS–Lettering and similar markings should be located on a surface approximately parallel with the mold parting line and in such position that there will be minimum restriction to metal flow and proper solidification.

Table III—Machine Finish Allowance for Castings

Metal	Pattern Size In.	Bore, In.	Finish, In.
Cast Iron	Up to 12	1/8	3/32
	13 to 24	3/16	1/6
	25 to 42	1/4	3/16
	43 to 60	5/16	1/4
	61 to 80	3/8	5/16
	81 to 120	7/16	3/8
	Over 120	Special Instructions	
Cast Steel	Up to 12	3/16	1/8
	13 to 24	1/4	3/16
	25 to 42	5/16	5/16
	43 to 60	3/8	3/8
	61 to 80	1/2	7/16
	81 to 120	5/8	1/2
	Over 120	Special Instructions	
Malleable Iron	Up to 6	1/16	1/16
	6 to 9	3/32	1/16
	9 to 12	3/32	3/32
	13 to 24	5/32	1/8
	25 to 35	3/16	3/16
	Over 36	Special Instructions	
Brass, Bronze, and Aluminum Castings	Up to 12	3/32	1/16
	13 to 24	3/16	1/8
	25 to 36	3/16	5/32
	Over 26	Special Instructions	

LOAD MARKING–For purposes of definition, structural Class A castings are those for which the ultimate allowable stress is less than 10 times the design ultimate stress; structural Class B castings are those for which the ultimate allowable stress is greater than 10 times the design ultimate stress. For structural Class A castings, the critical loads should be indicated on the drawing for use in testing. The point of application and direction of each load should be shown by a heavy arrow placed on the drawing, and the magnitude of the ultimate load indicated by placing the figure in pounds near the arrow. Reactions should be indicated, but values need not be given unless necessary to assure proper loading. Only one total load condition need be shown unless different conditions are critical on various parts of the casting. Structural Class B castings do not require load markings to be shown, but doing so helps in establishing the requirement of the castings.

INSPECTION NOTES–Casting drawings should specify method of inspection–such as, "radiographic inspection" or "magnetic inspection."

DIMENSIONING DRAWINGS–In order to eliminate the accumulation of tolerances, all locating dimensions in parallel planes should be from the same imaginary center line, base line, or basic surface of the casting, except where it is necessary to maintain a particular relationship between two or more surfaces or center-lines of bosses, clevises, hubs, bearings, or housing. Dimensions pertaining to the basic outline of the casting should be half the breadth, or length from the centerline to one surface, and overall widths or lengths to the opposite surface. Basic outlines should not be dimensioned from the locating center lines of corner radii. Draft should be provided on all surfaces which are normal to the parting plane. All machined surfaces, as well as bored or drilled holes should be dimensioned from a machined surface and this should be the one that is machined first and which will be used as an indexing surface in the machining fixture or drill. For sand castings, dimensions should never be closer than ⅛ in., and should be in fractions rather than thousands.

NOTES ON DRAWINGS–Casting drawings generally should include notes similar to the following:

Must be free from sand, burrs, shrinks and chilled edges.
Castings to be cleaned by sand blasting or tumbling.
Grind off all burrs, fins, etc., flush with contour.
Structural Class A (or B).
All corner radii ⅛ in. unless otherwise noted.

EDITOR'S NOTE—The present article does not cover investment casting or the frozen mercury process. For these processes see "Designing for Investment Casting" in April 1956 page 166 and "Frozen Mercury Process for Investment Castings," in the 1956 Design Digest Issue page D13.

Other recent articles on casting include: "Redesign for Die Castings," January 1956 page 156; "Evaluation of Casting Processes," March 1954 page 139; "A Practical Approach to Casting Design," July 1953 page 192; "How Design is Affected by Foundry Practice," February 1950 page 117.

Sheet Metal Joints for

Last month's article, "Sheet Metal Seams and Joints," discussed 14 seams and joints for flat sheets, can ends and irregular

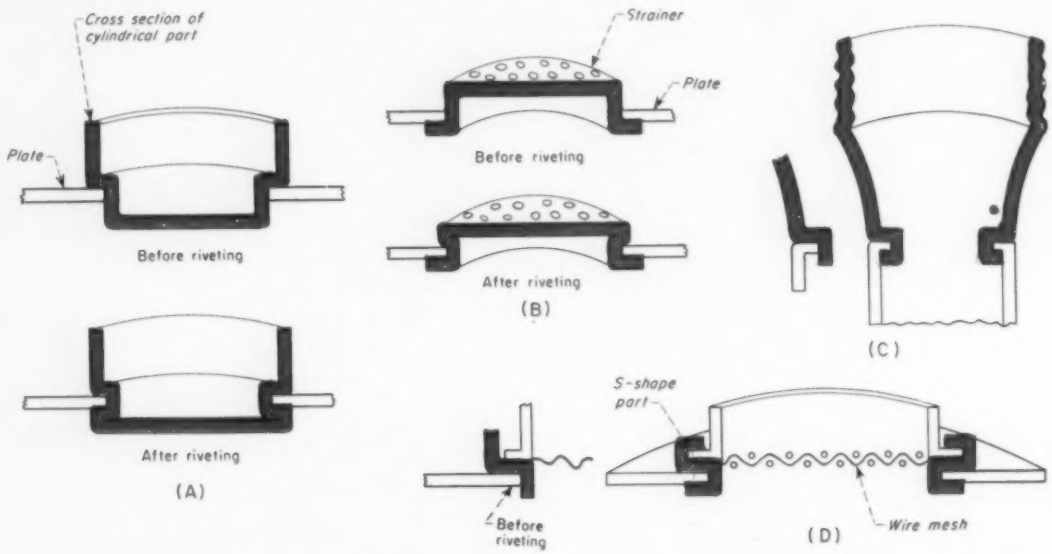


Fig. 1—(A) *Small diameter cylindrical shapes* can be inserted through hole in plate and riveted over, thus resembling extruded rivets. Examples: (B) strainer in a filter; (C) flashlight housing; (D) wire mesh in a sifter. S-shape part in (D) avoids using a complicated cylindrical shape which may be difficult to stamp.

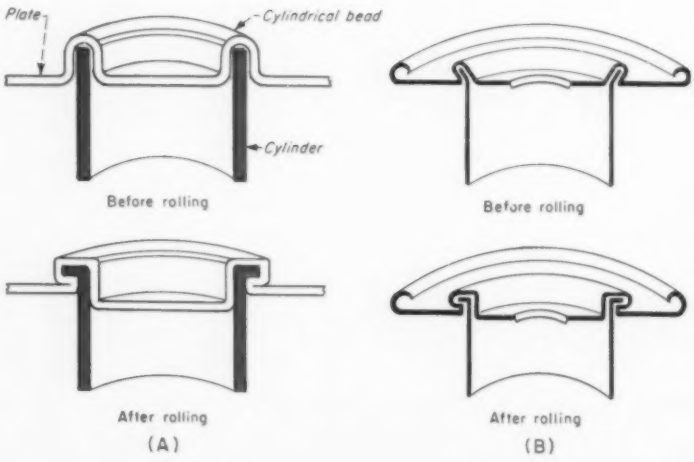


Fig. 2—(A) *Rolled cylindrical beads* make a strong joint. Bead is stamped into plate, and cylinder inserted into groove of bead. Bead is then rolled over outwardly in a press. (B) Similar construction for large-diameter spool head.

Cylinders and Boxes

W. C. MILLS

shapes. This article describes methods for joining cylinders to cylinders, cylinders to flat sheets, and square corner boxes.

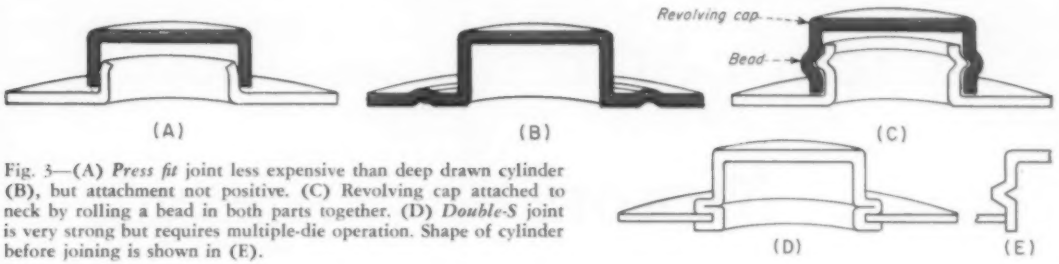


Fig. 3—(A) *Press fit* joint less expensive than deep drawn cylinder (B), but attachment not positive. (C) Revolving cap attached to neck by rolling a bead in both parts together. (D) *Double-S* joint is very strong but requires multiple-die operation. Shape of cylinder before joining is shown in (E).

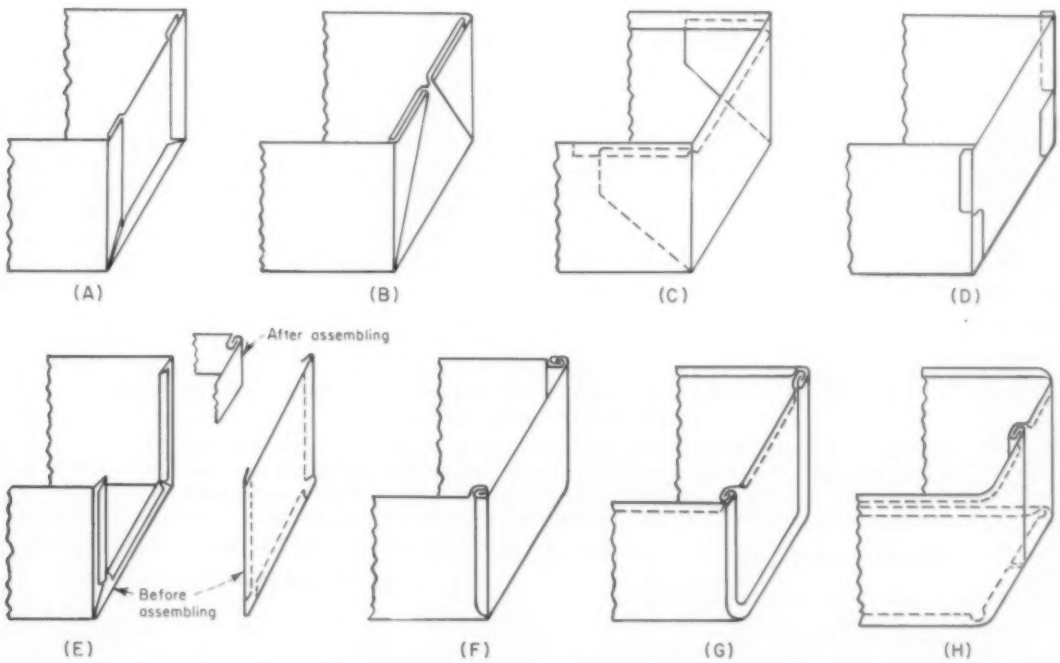


Fig. 4—*Square corner boxes:* (A) Separate ends welded to sides of box. This permits use of thick-gage steel for making heavy-duty boxes. Unlimited in size. (B) Leak-proof box is folded from one piece without notching. Appearance and groove in corners may be objectionable. (C) Notched and folded from a single piece of metal. Box is sometimes welded together but usually assembled with an overlapping hem. (D) Single-piece box notched and folded with tabs around corners; low cost construction suitable for shallow boxes. (E) Notched and folded with bumped-on end pieces; good appearance and economical in material. (F) Notched and folded with corners seamed with a progressive die; die is usually expensive and height of box limited to 3 in. because of stroke of punch press. (G) Box with bumped-on ends. (H) Lock-seamed and hemmed body with bottom curled in; good appearance.

Applying Single-Phase Capacitor-Start Motors

Effect of power supply, hp rating, duty cycle, and starting current limitations on motor choice; overload protection and mechanical features.

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Westinghouse Electric Corporation,
Sunnyvale, Calif.

APPLICATION OF SINGLE-PHASE CAPACITOR MOTORS requires a knowledge of following operating factors: (1) Line voltage and frequency; (2) horsepower rating, starting and running torque, and a description of the duty cycle; (3) NEMA and utility starting-current limitations; (4) automatic or manual-reset overload protection; and (5) enclosure and mounting.

Power Supply

The most common single-phase power in the U. S. is 115-230 volts at 60 cycles. Motors between ¾ and 5 hp are normally designed for both 115 and 230-volt operation; motors larger than 5 hp are often supplied only for 230-volts because power companies will not permit high starting and running currents resulting from a 115 volt connection.

Line frequency determines operating and transfer speeds. Transfer speed is that speed at which a capacitor motor changes from *start* to *run* connection. A 50-cycle motor has a lower transfer speed than a 60-cycle motor with the same number of poles and horsepower rating. Reduced transfer speed at 50 cycles requires a different speed-sensitive device to disconnect the start winding than that used for 60 cycles.

Single-phase capacitor motors may have a dual 50-60

Table 1—Torque and Current Characteristics, General Purpose, Single-Phase, 60-Cycle Motors of Synchronous Speeds Shown

Voltages of 115 and 230 are NEMA standard ratings for single-phase motors, but usual motor terminal voltages during running conditions on rural lines are 110 and 220 volts, especially for motors of 5 hp and up. Currents for 220-volt operation are based on maintaining the same locked KVA per hp as obtained from NEMA standardized 230 volt currents.

Hp	Torque, lb-ft						Locked-Rotor Current, amp, for Designs L and M			
	Locked-Rotor Starting, min.			Breakdown			230 volt		220 volt spec'al	
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm	L	M	L	M
¾	5.16–6.9	.....	.....	8.4	....	....	....	...	.....	.....
1	6.9–9.2	5.16–6.8	.....	10.3	9.4	....	35	...	36.6	.....
1½	9.2–13.8	6.8–10.1	3.6–4.6	14.0	13.3	4.3	50	40	52.3	41.8
2	13.8–18.0	10.1–13.0	4.6–6.0	17.3	16.8	5.9	65	50	68.0	52.3
3	18.0–25.8	13.0–19.0	6.0–8.6	24.0	23.4	7.7	90	70	94.0	73.2
5	25.8–40.5	19.0–30.0	8.6–13.5	NS	36.0	11.0	135	100	141	104.6
7½	40.5–60.0	30.0–45.0	13.5–20.0	NS	49.5	16.0	200	150	209	157
10	NS	45.0–60.0	20.0–27.0	....	....	....	260	200	272	209
15	.....	.....	.....	.....	....	....	390	300	408	314
20	.....	.....	.....	.....	....	....	520	400	544	418

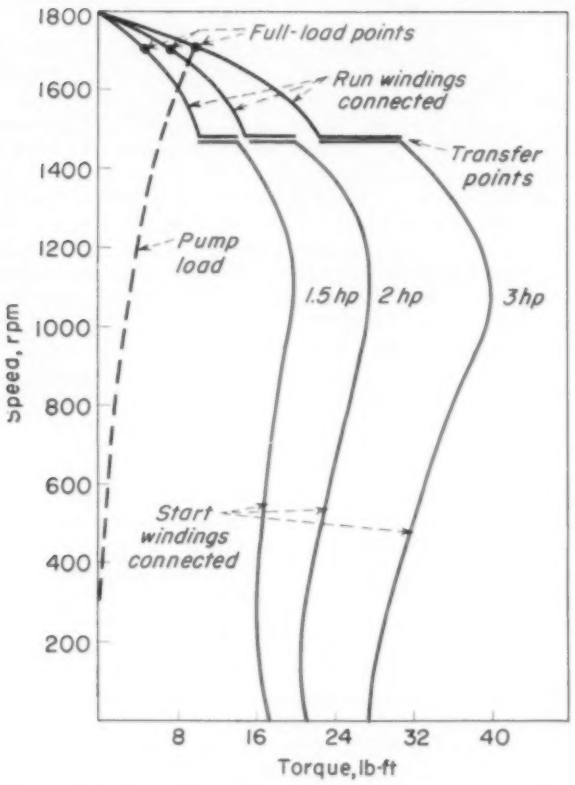


Fig. 1—Speed-torque curves of pump load evaluated against curves of 1.5, 2, and 3 hp single-phase motors to determine proper driving motor. Speed-torque curves of start windings are in red, those of run windings are in black. Load curve intersects run-winding curve of 1.5 and 2-hp motors at torques higher than full load; this results in an undesirable continuous overload. Curve of 3-hp motor is intersected at full-load torque and speed and is proper choice.

cycle nameplate rating such as commonly found on standard three-phase motors, but a 60-cycle single-phase motor operating on 50-cycle power will not meet guaranteed 60-cycle running performance because of increased losses. A dual-frequency motor is a compromise design in order to maintain performance at each frequency within established values. To obtain best motor performance at frequencies lower than 60 cycles, special electrical designs are required.

Horsepower Rating

Ratings for integral-horsepower single-phase motors are based upon breakdown torque developed at rated voltage and frequency. The minimum value of breakdown torque obtained from a given motor design determines the rating of that particular unit. Standard values for single-phase motor performance have been established by the National Electrical Manufacturers Association. Table I lists NEMA standards for breakdown and locked-rotor torque and starting current. Manufacturing variations may result in individual motors having breakdown torques which range from 100 to 115 per cent of value in Table I. This 15 per cent margin should not be relied upon when applying a motor.

For maximum motor life the nameplate hp rating should not be exceeded for continuous loads. Load characteristics can be determined by oscillograph or wattmeter readings obtained from a sample unit; where these are not available, an estimation of the load cycle can be based on previous performance of similar equipment. For example, Fig. 1 shows the speed-torque curve of a centrifugal pump superimposed on similar curves for three motors. The pump torque curve intersects the 3-hp motor curve at 9.3 lb-ft; the 2 hp curve at 8.8 lb-ft; and the 1½ hp curve at 8.0 lb-ft. The 2-hp motor has a full-load torque of 6.07 lb-ft and therefore would be operating with a continuous overload of 145 per cent. Similarly, the 1½ hp motor, with a full-load torque of 4.60 lb-ft, would be overloaded approximately 175 per cent.

Starting Current

Capacitor-start induction-run operation is used on ratings of less than 5 hp. To obtain standardized locked-rotor starting torques listed in Table I, Design L motors are used for most ratings smaller than 5 hp. There are, however, some 3600-rpm designs in which it is possible to obtain both standardized locked-rotor starting torque and the lower Design M starting currents.

For a number of years use of single-phase motors on rural and other distribution lines was limited by power companies to maximum ratings of 3 hp because starting inrush currents produced excessive line voltage drops. Motor manufacturers have since reduced starting currents and improved running power factor and efficiency on larger size ratings. As a result some utilities now permit installations of 7½ and 10 hp single-phase motors and in special cases up to 20 hp. This increase is made possible by capacitor-start capacitor-run motors using continuous-duty oil-type run capacitors which provide improved running power factor and efficiency. These larger horsepower motors have the Design M starting currents.

Overload Protection

Automatic or manual-reset overload protection can be obtained for 1800 rpm motors up to 3 hp. For larger motors a thermostat is commonly mounted on the winding, operating as an auxiliary control which stops the motor under abnormally high winding temperatures. For applications using conveyors or other machinery in which material can become jammed, manual-reset control is required protection to clear the obstruction before restarting the motor.

Mechanical Features

Single-phase capacitor motors are normally supplied with dripproof enclosures designed to prevent moisture

falling at an angle less than 15 deg from the vertical from entering the motor. Air openings on each end of the motor are provided with restrictions which prevent rodents from entering. Starting capacitors are normally mounted in a large conduit box on the outside of the motor, resulting in capacitor temperatures essentially independent of motor winding temperatures. Special brackets are available to adapt motor to commonly used pump mountings. If a motor is used on a vertical pump, motor bearings must be large enough to withstand the thrust loads developed.

New NEMA frame assignments for single-phase motors were adopted in 1953 consistent with the polyphase motor rerate program. The old and new frame assignments for both single and polyphase ratings are compared in Table II. Prior to the rerate program all single-phase 1800 and 3600 rpm ratings were on the same frame sizes as polyphase units, while most single-phase 900 and 1200 rpm ratings were one frame size larger than the corresponding polyphase motors.

The rerated assignments place the majority of single-phase ratings on the next larger frame size than polyphase units. In reassigning motor designs, the 200 and 220 basic series were dropped while new frame sizes, 180 and 210, were created.

Starting Period

To provide the large capacitor required for starting, dry-type nonpolarized electrolytic capacitors are used. The power factor of these capacitors at rated voltage varies from 5 per cent for small capacitors to 10 for large. Duration of motor starting period is primarily determined by the capacitor rating because of internal heating caused by dielectric leakage current. For example, Fig. 2 shows typical capacitor voltage during starting period; this voltage decreases while the motor is accelerating but as transfer speed is approached the voltage increases. Since capacitor voltage is fairly constant during this period the heating effect is uniform and capacitor temperature depends directly upon the number of starts per unit time.

To reduce heating, capacitor manufacturers recommend that duty cycles for single-phase motors do not exceed 20 evenly spaced starts per hour, each start being no longer than 3 sec. To increase the number of starts beyond this figure, the duration of each respective start must be decreased so that the total watt-second capacitor heat input does not exceed that of the recommended standard. When starts exceed 20 per hour it may become necessary to furnish starting capacitors with internal thermocouples in order to measure total temperature rise during an actual duty cycle and thus insure a safe capacitor temperature. At no time should the maximum internal capacitor temperature exceed 150 F.

To evaluate the life of electrolytic starting capacitors under different load and duty cycles it is necessary to know the total time the start winding is energized. To determine this, accelerating torque is averaged over the speed range from standstill to the transfer point. Torque available for load acceleration is the difference between motor and load torques. The time in sec required to reach the transfer point is given by:

$$\frac{\text{Motor and load } WR^2 \times \text{Change in speed, rpm}}{308 \times \text{Average accelerating torque, lb-ft}}$$

Average accelerating time on the start winding should be 3 sec or less if recommended operating time for electrolytic capacitors is to be maintained. If a general purpose motor is used to start a high inertia load the starting winding will usually be energized more than 3 sec. Hence, for applications having starting torques greater than the values presented in Table I, the selection of special motors with high starting torque is mandatory.

General purpose 115-230 volt motors are frequently used on 120-208 volt systems. The operation of a motor on reduced line voltage increases full-load current which, in turn, increases motor winding heating. Starting and running torques are decreased, possibly below NEMA standard values. A 220-volt motor operated on a 208-volt system will have approximately 89 per cent of rated starting torque; with loads having high breakaway torques the motor will require a proportionately longer starting time. Since the capacitors are energized for a longer than normal time, capacitor life decreases. Where performance of a 115-230 v motor is below normal, a special motor designed for operation at 208 v should be used.

Table II—Comparison of NEMA Frame Sizes for Open Type, 40 C Rise, 60 Cycle Single Phase and Polyphase Motors

For open type, 40 C rise, 60 cycle. Single-phase motors are 115–230 volt general purpose horizontal and vertical mounting. Speeds shown are synchronous rpm.

Hp	Single Phase				Polyphase			
	3600	1800	1200	900	3600	1800	1200	900
Prior to Rerating								
½				204				224
¾			203	224			204	225
1		203	204	225		203	224	254
1½	203	204	224	254	203	204	225	254
2	204	224	225	254	204	224	254	
3	224	225	254	284	224	225		
5	225	254	284	324	225	254		
7½	254	284	324	326	254			
Rerated								
¾			182				184	
1		182	184			182	213	
1½	182	184	184		182	184	215	
2	184	184	213		184	213		
3	184	213	215		213	215		
5	213	215	254U		215	254U		
7½	215	254U	256U		254U	256U		

Running Period

Once the motor meets starting requirements the running portion of the duty cycle should be checked for possible overheating of the run winding. Continuous overloading is inadvisable because the run-winding temperature rise is approximately proportional to the square of current increase. That is, a motor operating at 1.25 times full-load current would have a winding temperature rise 156

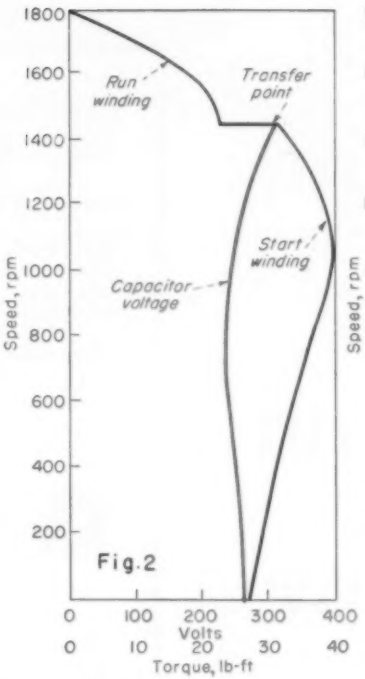


Fig. 2—Typical variation of starting capacitor voltage during starting cycle of 3-hp single-phase motor.

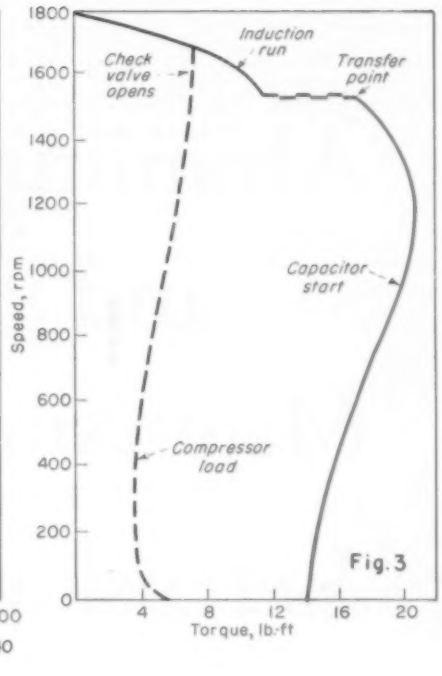


Fig. 3—Starting cycle of capacitor-start motor driving a compressor. Compressor bearing friction provides a 7 ft-lb load on starting; once shaft begins rotating load drops to 4 ft-lb, then gradually increases to full-load torque. Torque available to start load is difference between load torque and start winding torque.

per cent higher than rated full load. Under continuous overload, as in using the 1.5-hp motor in Fig. 1, the resulting temperature rise decreases motor winding life. Class A insulated motors are rated for a 40 C rise in winding temperature as measured by thermometer, when operating in a 40 C ambient and up to 3300 ft above sea level. At higher altitudes cooling is reduced and the motor rating selected should be increased sufficiently to maintain the 40 C rise.

Open and dripproof Class A insulated motors are allowed a 10 C service-factor rise which decreases as the horsepower rating increases. The following table lists standard service factor values:

Motor Hp	Service Factor	Allowable Added Temp Rise, C
½—1	1.25	10
1½—2	1.20	8
3 —Up	1.15	6

Breakdown torque rating of any motor should be used only to offset momentary overloads; if maximum load torque is greater than the run winding pull-out torque, an undesired continuous transfer between the run and start winding can result. To provide sufficient torque for duty cycle with peak demands, motors are designed for rms load torque with the run winding capable of meeting the peak load torque on lowest encountered line voltage.

Ambient Temperature

Prelubricated factory sealed anti-friction bearings used in single-phase motors are available for three classes of applications based on expected starting and operating temperatures for bearings. Normal operating temperature ranges from −25 C to 85 C. For operating temperatures below −25 C, such as in refrigeration service, special low-temperature greases are used. High-temperature applications from 85 C to 125 C use silicone grease. Bearings operating at temperatures above this range have shorter life than those operating under the limiting temperature.

When single-phase motors are applied in ambient temperatures that greatly exceed 40 C it is necessary to use Class B winding materials. Also a high ambient temperature may increase total capacitor operating temperature above the recommended 150 F; when this occurs the capacitor must be removed and mounted in a cooler ambient location. At low ambient temperatures the electrical capacity of starting capacitors decreases; this results in low starting torque and may require a special motor design.

On some duty cycles the motor is reversed; here, winding losses increase rapidly and may limit number of reversals. The type of control used to plug reverse the motor is dependent on the type of winding-transfer mechanism used in the motor, since in reversing rotation the motor speed must be reduced to the point at which the switch mechanism reconnects the start winding. For capacitor motors reversals must not exceed 20 per hr.

EDITOR'S NOTE.—Additional articles bearing on the application of single-phase motors and overload protection problems have appeared in past issues:

"Motors for Direct-Connected Fans," May 1956 page 194, tells how to select single-phase split-capacitor motors for fans or other equipment requiring maximum power for minimum current. The influence of power factor, efficiency, speed and starting torque on performance and cost are also set described.

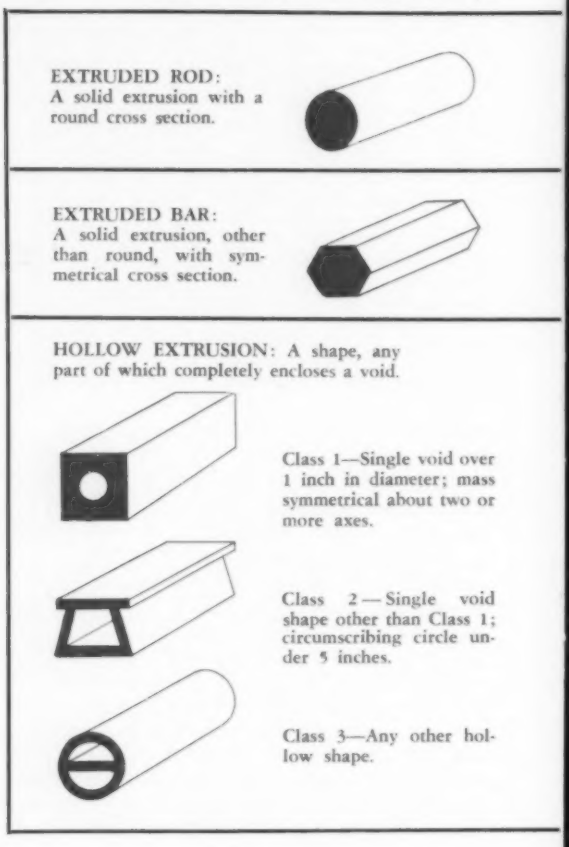
"Starting Methods," February 1956 page 183, describes various methods of motor starting to protect motors of 5 hp and up from undervoltage operation and at the same time prevent starting voltage dips from affecting operation of other motors.

"Motor Overload Relays," January 1955 page 177, presents fundamentals of bimetallic thermal overload relay operation as a guide to selecting the proper type and rating.

Aluminum and Magnesium Extrusions

. . . Classified by shape
. . . Alloys to use
. . . When to specify
. . . Evaluating proposed shapes
. . . Tolerances
. . . Costs

Table I—Types of Light Alloy


EXTRUDED ROD:
A solid extrusion with a round cross section.
EXTRUDED BAR:
A solid extrusion, other than round, with symmetrical cross section.
HOLLOW EXTRUSION: A shape, any part of which completely encloses a void.
Class 1—Single void over 1 inch in diameter; mass symmetrical about two or more axes.
Class 2—Single void shape other than Class 1; circumscribing circle under 5 inches.
Class 3—Any other hollow shape.

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Extrusions are produced by forcing softened metal through an orifice having the outline of the desired shape. The operation is performed in a slow-action press consisting of a heated chamber, a ram, and a die having a shaped orifice. A billet of metal is softened in the press by induction heating; when extrusion temperature is reached, the ram forces the metal through the die onto a receiving table in line with the press. After cooling, the extrusion is straightened by stretching and twisting. Finally, the extruded bar is heat treated, cleaned and cut to length.

This method produces shapes at reasonable cost which would be prohibitively expensive by casting, rolling or machining. Curved, angular and hollow sections are feasible, thus efficiently distributing the metal for optimum strength, weight, assembly or appearance. In general, desired shapes can be produced without compromising sound design.

Extruded shapes are classified into the seven basic types shown in Table I. For semi-hollow extruded shapes, the relationship between gap width and void area is given in Table II. Semi-hollow shapes with tongue ratios less than the minimum listed are classed as solid shapes.

Most of the metals extruded are non-ferrous. Carbon and stainless steel can be extruded, but poor drawing qualities limit their use. Most aluminum and magnesium alloys are extrudable. Commonly used alloys are listed in Table III with some of the advantages and limitations of each.

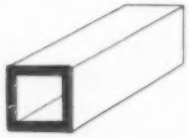
Physical properties such as strength, machinability, weldability and corrosion resistance are the same as for wrought alloys, except for somewhat greater limitations on bending and forming since extrusion produces an elongated crystalline structure. Except for 3003 aluminum and FS1 magnesium, strength may be increased by heat treatment following extrusion.

Major factors to consider when designing for extrusions:

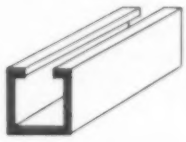
(1) Economy of metal distribution can be achieved. Table IV shows five examples of redesigning with extrusions.

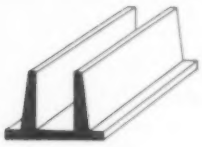
(2) Cost will depend upon the complexity of making the die, if a special configuration is required. Often the

EXTRUDED TUBING: A hollow section with one void enclosed by a wall of uniform thickness and symmetrical outline.

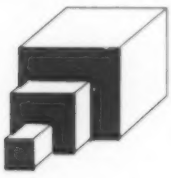


SEMI-HOLLOW EXTRUSION: A shape with a partly enclosed void. Ratio of void area to square of gap width conforms to Table II.



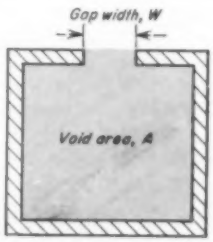


SOLID EXTRUSION: Any extruded shape other than hollow or semi-hollow.



STEPPED EXTRUSION: A solid shape with changing cross section along length. Transition may be gradual or abrupt.

Table II—Classification of Semi-Hollow Extruded Shapes



Gap Width, W, inch	Tongue Ratio
Less than 0.031	Over 1
0.031 to 0.061	Over 2
0.062 to 0.124	Over 3
0.125 to 0.249	Over 4
0.250 to 0.499	Over 5
0.500 and greater	Over 6

NOTE: Tongue ratios less than those shown classify part as a "solid" extrusion. Minimum gap width is 0.031 inch.

Table III—Common Aluminum and Magnesium Extruding Alloys.

Old No.	New No.	General Description
ALUMINUM ALLOYS		
3S	3003	Easily extruded in hollow and intricate shapes. Good corrosion resistance and weldability. For architectural shapes where great strength is not a requirement.
63S	6063	Moderate strength alloy. Easily extruded in complex, thin shapes with excellent surface finish. Corrosion resistance good. Alloy is easily welded and brazed. Often used in architectural shapes.
61S	6061	The strongest alloy available for hollow shapes. High strength combined with good corrosion resistability and weldability make it a good all-purpose extrusion alloy. Truck body and furniture shapes are typical uses.
14S	2014	A high strength alloy preferred for heavy, solid shapes. Legs thinner than 0.125 inch and walls thinner than 0.156 for enclosing a void are difficult to extrude. Unsuitable for fusion welding. Not applicable where good forming characteristics are required. Typical usage is in aircraft structures.
24S	2024	Mechanical properties lie between 6061 and 2014. Of limited workability, this alloy can be resistance welded but not fusion welded. Replaces 2014 alloy where leg and wall thicknesses of less than 0.125 inch are required. Greatest use is in aircraft.
75S	7075	Strongest of all the extrudable alloys; widely used in aircraft structures, it is the most difficult to extrude; not suitable where good forming qualities are required. May be resistance welded.
MAGNESIUM ALLOYS		
FS1		Most widely used magnesium extrusion alloy Moderate strength and good formability.
ZK60A		A high strength magnesium alloy with good toughness. Heat treatable.

problem can be solved using commercially available extrusions.

(3) Material selection also influences cost. A poor choice of alloys can increase the finished extrusion cost by as much as one-third. Alloys listed in Table III are in order of increasing extruding difficulty.

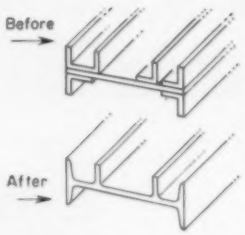
(4) Some shapes are more feasible to produce than others. A "Feasibility Factor" is useful in evaluating a proposed extrusion. One useful factor empirically relates the material, ratio of section perimeter P to section area A, and diameter of its circumscribing circle:

$$\text{Feasibility Factor } F = 0.833\ P/A$$

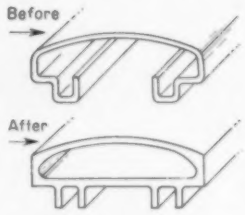
EXAMPLE: Assume a shape similar to that shown in Fig. 1 is needed, and strength considerations require either

Table IV—Redesigning With Extrusions

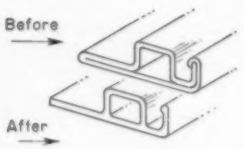
Double thicknesses of metal and close-quartered joints may be replaced by a single extrusion.



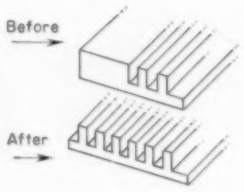
Variations in cross section are possible, allowing greater flexibility in design compared to roll-formed sheet sections.



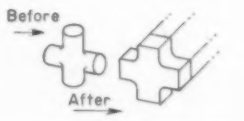
Members requiring several fabricating operations may be replaced by extrusions with greater rigidity and possible weight reduction.



Machined parts can often be replaced with shapes extruded to final dimensions.



Parts which have a uniform thickness in one profile may be cut from extruded stock to avoid forging or casting costs.



2014 or 7075 aluminum alloy. Can the section be extruded? Ignoring corner radii, the perimeter P is 15.25 in. and the area A is 0.94 sq. in. The Feasibility Factor F computes to 13.5. From Table V, for a circumscribing circle of 3.625 in., the Feasibility Factor must fall between 1 and 15. Therefore the shape, with a factor of 13.5, can be extruded from either alloy.

Extrusion tolerances are about the same as for rolled sections. The variation within a lot is usually a few thousandths of an inch, and is caused principally by die wear. Mating, sliding and dozetail parts are feasible with matched dies. Standard tolerances are shown in Tables VI and VII.

Aluminum and magnesium extrusions may be machined, fastened and welded using standard wrought alloy procedures. Forming and bending operations are somewhat more limited, however, due to crystal elongation induced by the extrusion process. This problem may be avoided by moderate pre-heating to about 400 F without loss of physical properties. Conventional forming and bending equipment may be used, although thin complex shapes should be stretch-formed to avoid wrinkling.

While extrusions are more expensive than rolled sec-

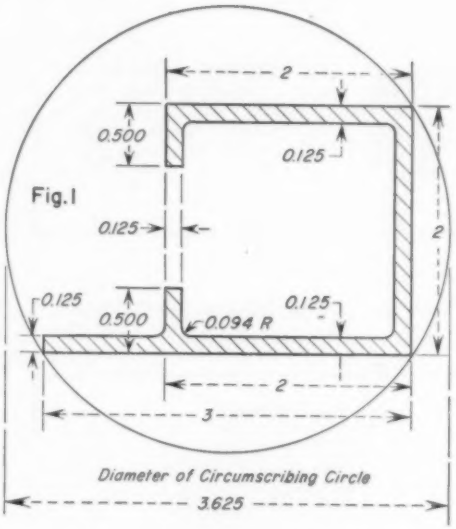
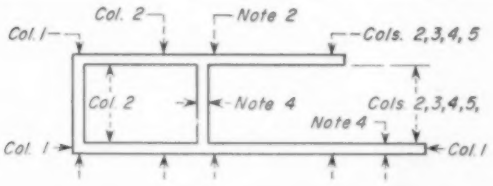


Table V—Extrusion Feasibility Factors

	Diameter of Circumscribing Circle, in.								
	Up to 1	1 to 1.99	2 to 2.99	3 to 3.99	4 to 5.99	6 to 7.99	8 to 9.99	10 to 11.99	12 to 14
ALUMINUM ALLOYS									
3003, 6061, 6063	1–29	1–29	1–29	1–19	1–17	1–15	1–13	1–12	1–10
2014	1–29	1–29	1–23	1–17	1–15	1–12	1–8	1–8	1–6
2024, 7075	1–23	1–19	1–19	1–15	1–12	1–11	1–8	1–5	1–4
MAGNESIUM ALLOYS									
FS1, ZK60A	1–29	1–29	1–23	1–17	1–15	1–12	1–8	1–8	1–6

Table VI—Standard Cross-Section Tolerances

Specified Dimension, in.	Tolerances, in., plus or minus[1]				
	Metal Dimensions	Space Dimensions			
	Allowable deviation where 75 per cent or more of dimension is metal, except for wall thickness completely enclosing space 0.11 sq. in. and over.[4]	Allowable deviation where more than 25 percent of dimension is space.[2,3]			
		0.250–0.624 in. from base of leg	0.625–1.249 in. from base of leg	1.250–2.499 in. from base of leg	2.500 in. or more from base of leg
	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
Under 0.125	0.006	0.010	0.012	0.014	0.016
0.125–0.249	0.007	0.012	0.014	0.016	0.020
0.250–0.499	0.008	0.014	0.016	0.018	0.022
0.500–0.749	0.009	0.016	0.018	0.020	0.026
0.750–0.999	0.010	0.018	0.020	0.022	0.030
1.000–1.499	0.012	0.020	0.022	0.026	0.034
1.500–1.999	0.016	0.024	0.028	0.034	0.050
2.000–3.999	0.024	0.032	0.036	0.048	0.064
4.000–5.999	0.034	0.042	0.050	0.064	0.088
6.000–7.999	0.044	0.054	0.062	0.082	0.112
8.000–9.999	0.054	0.064	0.074	0.100	0.136
10.000–11.999	0.064	0.074	0.088	0.116	0.160
12.000–13.999	0.074	0.084	0.100	0.134	0.184
14.000–15.000	0.080	0.090	0.106	0.142	0.196



[1]When a dimension is composed of two or more indicated components, the tolerance is the sum of the component tolerances.
[2]At points less than ¼ in. from base of leg, tolerances of Column 1 apply.
[3]Where the space is completely enclosed, tolerances of Column 3 apply.
[4]Tolerance on wall thickness shall be ± 10 per cent of mean wall thickness, max ± 0.060 in., min. ± 0.010 in. (Mean wall thickness is the average of two thicknesses on opposite sides of void.)

tions, costs may be reduced by tailoring the shape to the job as indicated in Table IV. While extrusion costs depend largely upon shape, extrusions in quantities over 5000 lb cost about $0.60 per pound for a low Feasibility Factor, to about a dollar per pound for a high factor. An exception is ZK60A magnesium which runs from about $1.25 to $1.75 per pound. For less than 5000 lb, an added charge varying from $0.30 to $1.00 per pound is required as the quantity decreases.

Extrusion dies for these light alloys are relatively inexpensive; die costs vary from $60 to $250 for solid shapes, and from $200 to $500 for semi-hollow and hollow shapes depending upon their complexity and size.

EDITOR'S NOTE—A discussion of heavy section aluminum extrusions being produced for the Air Force will be found in "Aluminum Extrusions from Heavy Press Program" by R. L. Hugo, August 1955 page 150.

F. M. Mallet's article, "Reducing Cost of Extrusions," June 1951 page 149 presents additional detail on evaluating proposed configurations.

See also "Extruded Low Carbon Steel" by R. L. Hugo, July 1955 page 129, for information on recent advances in ferrous extrusion technology.

"Cold Extrusion of Metals," page D-30, 1954 Product Design Handbook, describes the cold-forming of finished parts from low carbon steels.

Table VII—Standard Tolerances for Aluminum and Magnesium Extrusions

Type of Tolerance	Basis	Tolerance
Angularity.....	Minimum leg thickness:	
	through 0.187 in.	± 2 deg
	0.188 to 0.749	± 1½
	0.750 to solid	± 1
Corner and fillet radii	Sharp corners:	+ 1/64 in.
	Radius through 0.187 in.	± 1/64 in.
	Radius 0.188 and up	± 10 per cent
Length	Up to 10 ft	+ 1/16 in.
	10 to 30	+ 1/4
	30 and up	+ 1/2
Straightness	Circumscribing circle diameter:	
	through 1.499 in. min. thickness through 0.094 in.	± 0.0500 in. per ft.
	min. thickness 0.095 in. and up	± 0.0125
	1.500 and up	± 0.0125
Twist	Circumscribing circle diameter:	
	Through 1.499 in.	± 1 deg per ft.
	1.500 to 3.000	± 1/2
	3.000 and up	± 1/4

TECHNICAL NEWS

Platen is coming down on die which will cut patterns from several layers of material. Wheel at top, far right, is for adjusting platen to most effective height.

Conductive Working Surface Controls Cutting Machine

Combining a unique built-in stroke length regulator with a high element of safety, this hydraulically operated Hytronic Cutting Machine developed by the United Shoe Machinery Corp., of Boston, Mass., is finding many applications outside the shoe manufacturing business. Originally designed to cut out patterns of leather used on the upper portion of the shoe, it can be used to cut gasket material, clothing, various fabrics, sporting goods such as baseball gloves, and for trimming plastic parts.

In changing from one of the above operations to another, the machine requires no stroke adjustment to accommodate the different materials, and surface variations, other than adjusting the beam to the highest die used. A pressure setting switch, which is controlled by the operator acts as a pressure control to take care of unusual cutting conditions. This switch, which performs the function of a time delay (from 30 to 200 milliseconds), permits additional pressure to be exerted during cutting before the reversing action of the beam takes place. The key to this operation is a working surface (shown here partially hidden by the sheet of leather from which designs have been cut) which is made of an electrically conductive rubberized composition.

When the cutting die penetrates the material being cut and touches the working surface, a detection circuit is completed, and the cutting beam or platen (shown under operator's left hand) immediately reverses its downward direction and returns to its starting position. A high-speed hydraulic valve controlled by the electronic control system reverses the beam in a total of 30 milliseconds after the signal has been received. With this automatic stroke control feature the cutting beam, with a capacity of 30,000 lb, can cut a single ply of leather or other material up to 2¼ in. thick, or a single sheet of paper in succeeding operations without adjustment.

After the operator has placed the die in the desired position on the material to be cut, the cutting beam which swings with the column at left, is placed in position over the die, and the actuating button on top of the handle in the operator's right hand starts the beam in its downward direction. The control system is predicated on the fact that most of the materials that will be cut are nonconductive. In those instances where the material is conductive, it must be insulated from the cutting surface. While this is an unusual situation, the insulation can be effected by a sheet of paper. Or, the time delay device previously mentioned can be increased to prevent the cutting beam from reversing immediately upon contact with the material.

A cutting pad wedge, which increases or decreases the effective pitch to overcome deflections in the machine is used for the difficult-to-cut materials like nylon and asbestos.

The electronic control device is simple and fail-safe. If the circuit is

A single piece of leather is cut after operation at left. No machine adjustment is necessary, for platen backs off after material is cut and die contacts the conductive surface.

not in order, the cutting cycle will not be initiated. The inherent safety aspect included here is that if the operator when tripping the machine, inadvertently contacts the striking face of the beam, the detection circuit is completed, and the beam backs away.

The hydraulically operated machine is completely self-contained as shown and requires 25 per cent less floor space than the previous mechanical machines. In the hydraulic system standard components are used with the exception of the high-speed hydraulic control valve which was designed by United Shoe Machinery Corp. Minimum floor vibration results in less operator fatigue, and the die life is increased due to the hydraulic action. The pressure generated is only sufficient to complete the cut. Limiting controls prevent the system from exceeding 5100 psi.

Automotive Gas Turbine Wheel Cost Down to $10

Just one year ago, Dr. A. A. Kucher, director of the engineering staff of the Ford Motor Co., said, "One blade for a gas turbine for an automobile costs, right now, about $54; we want to get that cost down to about $25.00 for the whole turbine wheel."

At that time the price of a gas turbine engine for a car was estimated to be about $15,000, and the industry knew that if the gas turbine was going to be any sort of competition to the conventional engine it had to be competitive in price. That meant bringing the cost of the entire gas turbine engine down to about two or three hundred dollars.

One auto company in Detroit, which prefers to remain anonymous, has recently produced, by means of investment casting, a complete turbine wheel for less than $25. What's more the company expects to be able to produce the wheel in quantity for less than $10 a unit.

The wheel they have already made is cast out of regular aircraft alloys that contain about 60 per cent cobalt and some nickel. The company also states that they now have alloys that can be used in a gas turbine wheel that contain no strategic materials whatsoever. These alloys will go into the $10 turbine wheel.

The same auto company that has made the turbine wheel has also been experimenting extensively with new alloys, and have made great strides in the substitution for stainless steel in the turbine regenerator. Recent discoveries show that less and less stainless is needed in the regenerator, and in the easily-foreseeable future none will be needed at all.

Regenerators in the latest automobile gas turbines have succeeded in capturing 87 per cent of the exhaust heat from the turbine. A 70 per cent recovery of exhaust heat in a larger stationary turbine installation is considered about tops.

This same automobile company claims that: "The thermal efficiency of the gas turbine—now—has a greater potential than the thermal efficiency of any projected reciprocating engine of the future—and this efficiency is only the beginning. We have only tried, so far, to match the performance of critical metals with cheaper substitutes. We have been quite successful."

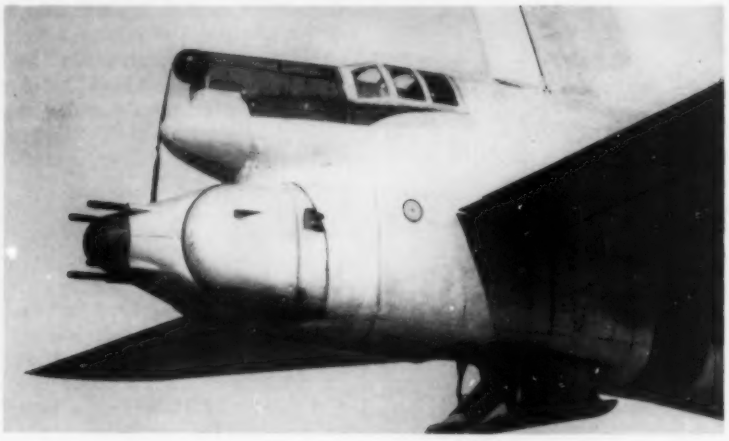
Most important step now facing the automotive people is the development of a whole new set of production techniques in the working of new alloys. Techniques already in use in the aircraft industry, to work turbine alloys are virtually useless.

That the industry will switch to gas turbines in a hurry, now that the biggest problems seem to be conquered, is not to be expected. Vast investments are represented in engine plants; enormous sums would be required to retool for a turbine program. And the calendar year of 1956 is not the sort of year that tends to loosen the purse-strings of the major auto companies.

In fact, the very people who have led the parade in the development of the new alloys say that in their opinion the talked-about 1963 to 1965 introduction date still looks about right.

Because the amount of tooling and machining per turbine unit will remain about parallel with the current reciprocating engine requirements, over-all retooling by the industry would result in astronomical expenditures. One important note was made in talking about the new alloys; every effort is being made to stay away from vacuum-melting techniques.

TECHNICAL NEWS



Radar Tail Unit Sole Defense For B-52

The problem of aerial defense in today's age of increasing speeds has been removed from human control and placed within a series of radar screens and black boxes. The B-52, America's eight engine retaliatory bomber, will rely upon a complex defensive system which has been designed by American Bosch Arma Corp., Garden City, N. Y.

According to officials at the Arma Corp., from the time the system sights a target, which is before the human eye can see it, until the time the guns are aimed for a kill, no more than three seconds elapse. During this brief time, full information as to distance, direction and speed of the target is gathered; the fire control problem is set up and solved; the guns are trained with proper lead; and a gunner is signalled to squeeze his handgrip. Range, range rate, angular positions, own speed, enemy's speed, air temperature, altitude, roll and pitch of own ship, trajectory characteristics and other factors are involved and are continually changing.

While the human element is necessary to control the action of the device, the problem of identifying friendly or hostile aircraft at night and at supersonic speeds is not done within the defensive unit but probably by means of another electronic system on the B-52. Although the angular coverage of guns within the turret is greater than 90 deg, the reliability of a single defensive unit, located in the tail of the plane, may be questioned. Save for its speed, the plane is vulnerable to side or frontal attacks. The electronics defensive system can be adapted to most caliber weapons; however, the B-52 is presently relying on four 50 caliber machine guns.

National Bureau of Standards to Relocate

The National Bureau of Standards, presently located in Washington, D. C., will be relocated on a 550 acre tract of land near Gaithersburg, Md. The move will permit the Bureau to plan new buildings to replace present research facilities, which over the past 50 years have become inadequate for current needs.

The new site will provide the benefits of a rural location where scientific programs can be undertaken without interfering in community life and without urban interference to important Bureau projects. The new location will remove the Bureau's work from the variety of mechanical, electrical, and atmospheric disturbances present in a city and will reduce the effect of these forces upon precise scientific measurements. Transfer of operations is expected to be completed in about five years.

Now: Mass Produced Nuclear Reactors

The term "mass-production" has finally reached the nuclear reactor with the announcement by Aerojet-General Nucleonics, San Ramon, Calif., that it is beginning the world's first mass-production of small, portable, self-contained nuclear reactors. By using a new method of core fabrication with a radiation stabilized polyethylene moderator, the reactor resembles a liquid homogeneous reactor but actually has a solid homogeneous core.

The requirement for critical mass is approximately 600 grams of Uranium 235 of 20 per cent enrichment, which is less than any known reactor. In addition, the quadruply sealed solid core locks in the fission products, eliminates the problem of waste disposal and prevents the escape of radioactive particles. Under normal operating conditions the core life exceeds 300 years. Along with the normal reactor safety interlocks, a thermal safety fuse is built into the core of the AGN 201 to increase the over-all reactor safety. Reactor safety and control rods are actuated from the reactor control console.

The reactor, called the AGN 201, is expected to be used as an educational device training students, military men, and medical research scientists. Its portability allows it to be placed in an ordinary room.

Users of Radioactive Isotopes Increase

According to a report just released by the Atomic Industrial Forum, Inc., the number of industrial users of radioactive isotopes has increased more than 500 per cent within the past five years. More than 1000 industrial firms in the U. S. are now using atomic energy by-products in 1347 different installations.

These radioactive materials supplied by the Atomic Energy Commission are being used for gaging and control operations in the manufacture of a variety of consumer products including roofing and flooring materials, paper, steel, textiles, rubber, plastics, glass and cigarettes. About 350 firms are using radioisotopes for the inspec-

tion of welds and castings, which means an annual savings to industry of about $200-million.

Research, development and testing organizations account for the largest number of organizations (120) using radioisotopes, with manufacturers of electrical equipment, electronics, and instrumentation (108); the metal working industry (107); paper-plastics (80); chemicals (62); petroleum and allied products (60); and machinery (52).

The Atomic Industrial Forum has compiled a listing of all the industrial organizations licensed by the AEC to use radioactive isotopes since the beginning of the program in August 1946, up to February 1956. The report, which is available from the Forum ($2.50) at 260 Madison Ave., New York 16, N. Y., also include: the name of the isotope; the year of for license; the purpose and company and subject indices.

Professional Employees and Unionism

A legal dispute which may effect the engineering profession evolved when the National Society of Professional Engineers asked the U. S. District Court for the District of Columbia to rule that the Taft-Hartley Act gives professional employees the right to a separate vote to determine whether or not they want to continue representation for collective bargaining by a trade union.

The Society filed its views in a "friend of the court" brief in support of a group of engineers at the Jersey City, N. J. Westinghouse Company. The engineers have filed suit against the National Labor Relations Board following an NLRB decision denying them a separate vote to determine their desires for future representation. They are now represented for collective bargaining by the International Union of Electrical Radio & Machine Workers, AFL-CIO.

In its brief, NSPE stated that the legislative history of the Taft-Hartley Act proves that Congress intended that professional employees were intended to have the right of a separate vote in all forms of representation proceedings. Original testimony to Congress underscored this point.

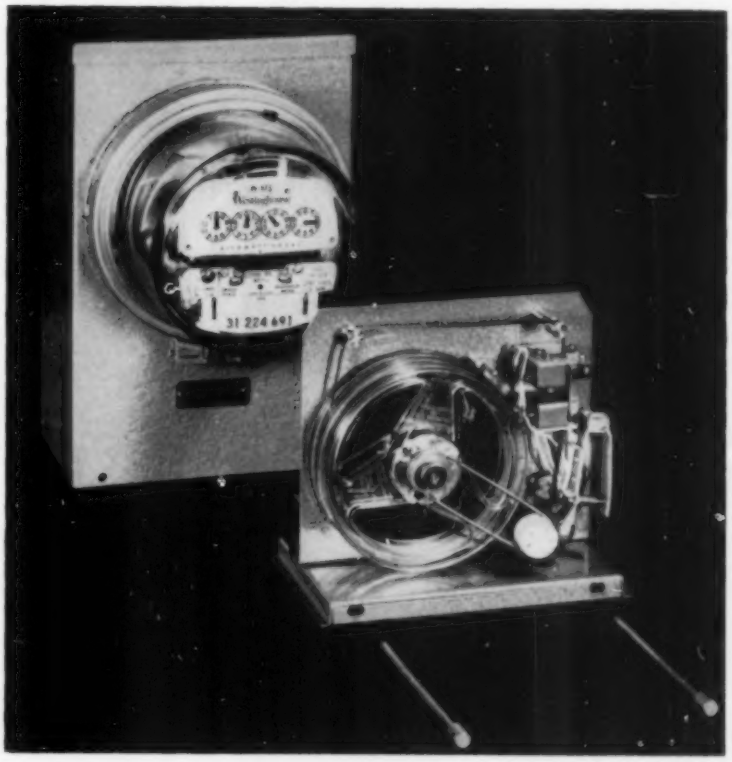
Under the Taft-Hartley Act, the brief says, employees are entitled to refuse collective bargaining as well as to accept it. This rebuts the language of the NLRB in its decision denying the Westinghouse engineers an election in which it was indicated that it would not be desirable to allow a separate election for the professional unit because the result might be their not being represented for collective bargaining.

Electrical Load Survey System Records Data on Tape

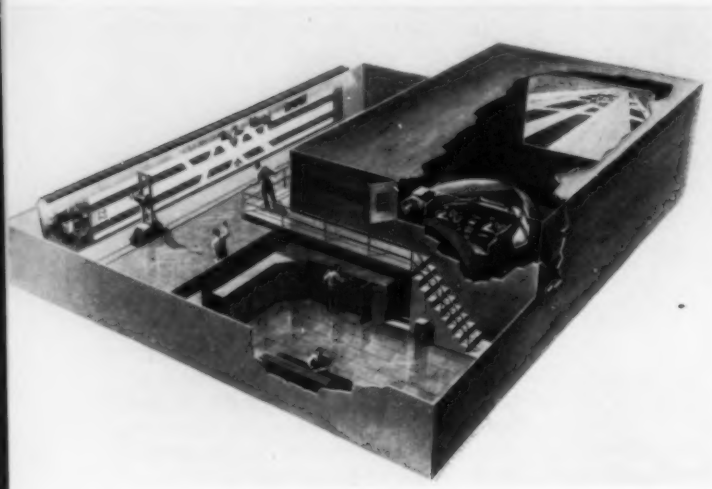
In a new system for load surveying developed by the Westinghouse Electric Corp., the survey data is transferred from a recorder installed at the customer's service to punched cards without any need for human interpretation.

The complete survey system includes a recorder that transcribes load and time quantities as impulses on magnetic tape; a translator that interprets these impulses as demand values; and a summary card punching machine such as IBM's number 526 which transcribes demand values to standard cards, pre-punched to include basic survey information. Since all of the functions except data gathering are concentrated in the translator and card punch machine as central office equipment, the recorder is sufficiently simple, and rugged for field installation. According to Westinghouse, the survey system was developed to study effects of increasing residential loads on utility systems.

Using standard 600 ft lengths of dual track magnetic tape at a recording speed of 9.4 in. per hr will permit a 32 day survey run unattended.



THE NEWS IN PICTURES



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USING TELEVISION to give a lifelike view of an airport on landings or takeoffs is part of a new ground training system for jet transport pilots. The system projects on a 15 ft screen a picture which reflects changes of perspective, attitude and motion caused by whatever action a pilot may take within a simulated cockpit. The picture is that of a three-dimensional scale model representing a typical airport landscape. A number of these map-like models can be stored and used whenever desired. The system is hydraulically actuated and incorporates pitch, vertical acceleration effects and roll, including rough air and buffet conditions. An added feature will be the incorporation of weather radar simulation. Called the Telerama, the device was developed by Douglas Aircraft Co. and can be used with the DC-8 flight simulator now being manufactured by Link Aviation, Inc.

THIS HYDRAULIC PRESS BRAKE forms up to seven different angles in succession without resetting controls. All bends on a piece of metal are formed in one handling by pre-setting controls but once. Range is from 12 in. deep bends formed in a single stroke to bends of less than $\frac{1}{8}$ in. with press cycling at 50 strokes per min or more. A piece can be passed from die to die for blanking, deep drawing, embossing, punching and forming. The unit can be used for straightening, stretching, extruding, and shearing heavy plates. Manufacturer is: Pacific Industrial Mfg. Co., Oakland, Cal.

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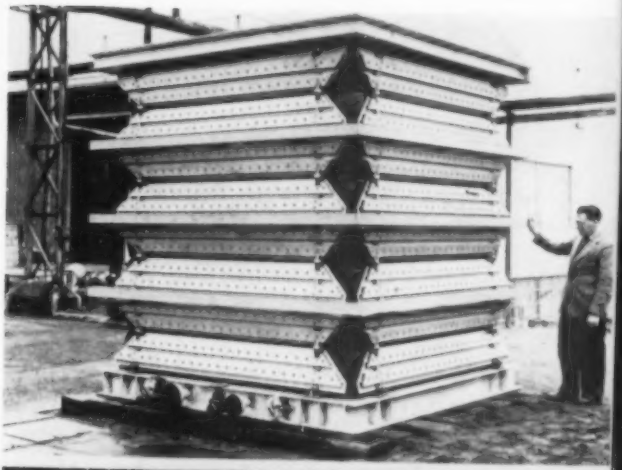
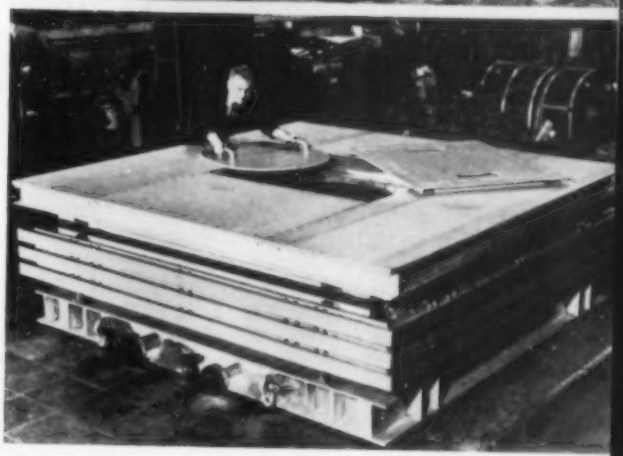
THIS STROBORADIOGRAPH, an X-ray picture of a 2 hp, 4 cycle gasoline engine, was taken with the combination of a 15 million volt betatron and special strobographic equipment shown in the background. The "stop" action in the X-ray photo was obtained by superimposing several thousand short exposures synchronized with the pulses in the engine cycle. The new process developed by the General Electric Co. for the Detroit Arsenal Labs. will show possible flaws or inefficiency of moving parts of engines or other equipment running at high speeds under varying load conditions.

USED PRIMARILY FOR PRODUCTION INSPECTION, this mobile X-ray unit will show debris and any foreign material in the inaccessible areas of an airplane, as well as detecting any mechanical or structural deficiencies. The unit is mounted on a custom chassis truck 15 ft long on which is mounted a 160 kv X-ray machine, and a hydraulically operated, telescoping mast with a retracting boom which carries the X-ray tube head. Operated from a control panel on the truck, the mast can be raised to a maximum height of 40 ft and the retracting boom can be extended 10 ft and rotated through 360 deg to give complete accessibility. The unit was designed by Douglas Aircraft Co., Inc., of Santa Monica, Calif.

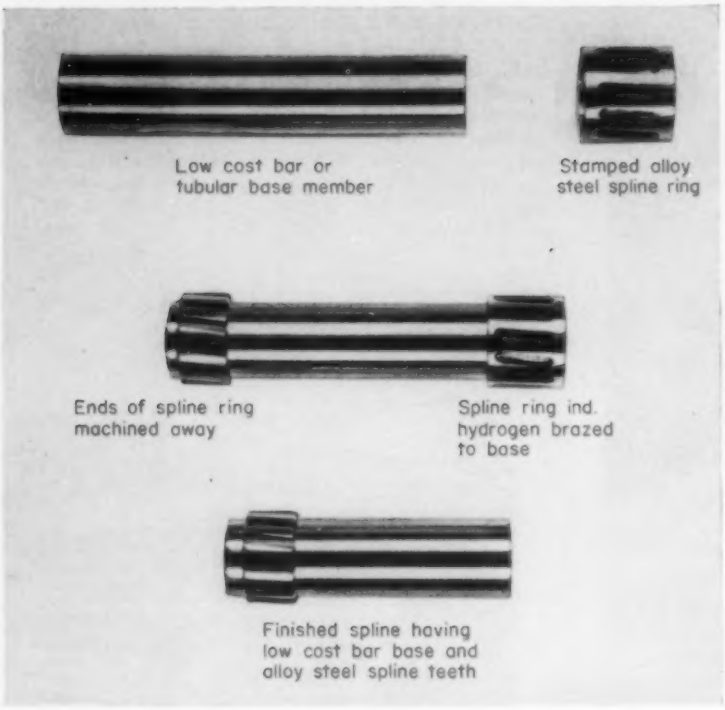
A MAGNETRON capable of supplying input power pulses of about 23 megawatts at 60,000 volts has been developed by the Westinghouse Tube Div., Elmira, N. Y. The tube, designed as the heart of what is said to be the most powerful shipborne radar set, weighs about 60 lb with a permanent magnet weighing 300 lb. A cathode was built to operate at temperatures up to 3100 F containing transparent vacuum-tight portholes for the passage of radar waves. The magnetron operates as a sealed oscillator, using water and forced-air cooling. No pressurizing or auxiliary jar insulation is needed. The tube will permit the detection of planes 400 miles away.





A COLLAPSIBLE TANK that will allow a ship to carry liquid cargo in one direction and dry cargo on the return trip was recently tested in Britain. The tank consists of a fabric-reinforced synthetic rubber bag contained in light alloy telescopic shuttering, (top picture). When empty the tank can be collapsed (bottom picture) in order to conserve space or act as a floor for temporary storage. The unit is manufactured by Marston Excelsior Ltd., Wolverhampton, England, and is available in three sizes: 1620 gal, 2260 gal and 2900 gal.

TECHNICAL NEWS



New Process Cuts Spline Manufacturing Costs

In the many cases where a spline cannot be rolled, a new process known as the Olson Spline process is said to offer an answer to the problem. This can be used where the spline is formed on tubular members, internal or external, and the concentric spline now used in many automatic transmissions, where tube over tube is splined to various drive members. Also, the process is said to offer exceptional cost savings combined with high volume production.

Basically, the process involves a low cost base member, solid or tubular, to which is brazed a high alloy tooth, inside or outside. The ends of the spline ring are then machined away leaving the finished spline as shown in the illustration. The pitch can be set in the stamping as required.

The process uses copper-hydrogen brazing to attach the spline teeth to the base, providing a high-strength bond. However, according to Olson, under high torque the teeth will "move" slightly until all of the teeth make contact with the mating member. This differs from the cut or rolled spline, where because of manufacturing tolerances, only one or two make the initial contact. Since this tooth cannot "move" under high torque load, it usually results in the failure of the spline.

The big cost saving is in the basic material. Only a high alloy tooth need be used on an inexpensive shaft material. As an example: take a shaft 6 in. long made from SAE 3140 forged steel. The blank cost $0.72 plus the machining cost to make the spline teeth. The Olson process would require only $0.14 in basic material, plus a brazing and machining cost of less than $0.05. This is due mainly to the use of ordinary cold rolled steel for the base member, plus a small amount of SAE 3140 material for the spline ring.

Another feature is the heat treatment and the coined tooth forming at the time of stamping. Developer of the new process is Renco-Toledo, Inc., 3358 Alexis Road, Toledo 7, Ohio.

Trend to V-8's and Automatic Transmissions

As an indication of the increasing demand for V-8 engines, these are production schedules on six-cylinder engines versus V-8's for the Ford, Chevrolet and Plymouth lines over the past three years.

Chevrolet in 1954 produced only 6-cyclinder engines. In 1955 6-cylinder production slipped to 56.8 per cent of the total and V-8 production stood at 43.2 per cent. In 1956 models the 6-cylinder production dropped to 42.7 per cent and V-8 production was up to 57.3 per cent.

Like Chevrolet, Plymouth made no V-8's in 1954 at all. In 1955 6-cylinder production was 54.9 per cent and V-8 production was 45.1 per cent. In 1956 6-cylinder production had dropped down to 35.7 per cent.

Ford production of 6-cylinder engines in 1954 was 26 per cent; V-8's 74 per cent. In 1955 the production of 6-cylinder engines had slid downward to 12.1 per cent and the V-8 had climbed up to 87.9 per cent. In 1956 6-cylinder production is estimated at about 10 per cent with V-8's taking the rest of the production output.

Interesting also is the climb of automatic transmission in the cars in the so-called low price field. Ford put automatic transmission into 39.4 per cent of its cars in 1954. In 1955 this rose to 57 per cent, and in 1956 it will hit about 64 per cent. Plymouth installed automatic transmissions in 36.7 per cent of its cars in 1954. In 1955 this rose to 46.9 per cent, and in 1956 it will hit about 62.3 per cent. Chevrolet had automatic transmission in 41.1 per cent of its 1954 output. In 1955 it rose to 53.7 per cent, and in 1956 it will be about 60 per cent.

All the figures quoted above are for calendar years—not model years.

London Group to Study Computers

A newly formed London Computer group has as its aim to bring together, as individuals, members of widely different professional and business activities who have a common interest in the design and application of elec-

tronic computers. Chief object of the group is to provide, through small study groups, the means whereby individuals with different professional interests may examine a common problem in computer use. To date, 15 study groups have been planned The group recently held its first convention, which was attended by 150 of its more than 250 current members. The group presently consists of London companies, however, those interested in obtaining information about membership and group activities may write: Joint Honorary Secretaries, London Computer Group, 19A Coleman St., London EC 2, England.

Studebaker Consolidates to Make a Profit

After 30 days under the advisory management agreement with Curtiss-Wright Corp., Studebaker-Packard Corp. announced a program whereby the company hopes to make a profit without increasing its present share of the market (1.58 per cent). The three-part program will mean: (1) a cost reduction plan based on not one extra man, machine, or foot of floor space; (2) a market development plan to support the present dealer organization; and (3) a product development program which emphasizes the price areas of the auto market in which the company's products are strongest.

The seven initial cost reduction moves are: concentration of both Packard Clipper and Studebaker production in the same facilities in South Bend with the beginning of the 1957 models; discontinue all automotive assembly operations in Detroit and Los Angeles; transfer of the Utica, Mich. parts and accessory division to South Bend; consolidate truck manufacturing operation in one plant; combine the Packard Clipper division and the Studebaker division factory and field sales personnel into one department; production of many of the components formerly purchased elsewhere; and rearrange and modernize existing facilities in order to aid materials handling procedures.

The 1957 Studebaker will be introduced Nov. 1, and the Packard sometime next January.

Microwave Display Tube in Small Package

A new microwave display device, a combination picture tube and traveling wave tube has been called the Wamoscope by its designers, Sylvania Electric Products, Inc., 215 Market St., San Francisco, Calif. Its immediate uses are in radar, but it will make possible the elimination of much of the currently used circuitry and chassis material to permit a simplified "bottled" television wrapped up in one glass envelope. It incorporates most of the essential features of a microwave receiver, and consists of a traveling wave tube and cathode ray tube separated by a special electron-optical system. Although the Wamoscope has a 5 in. bulb and a P-7 phosphor, there is no practical limitation to either the size of the face of the tube, or the type of phosphor used.

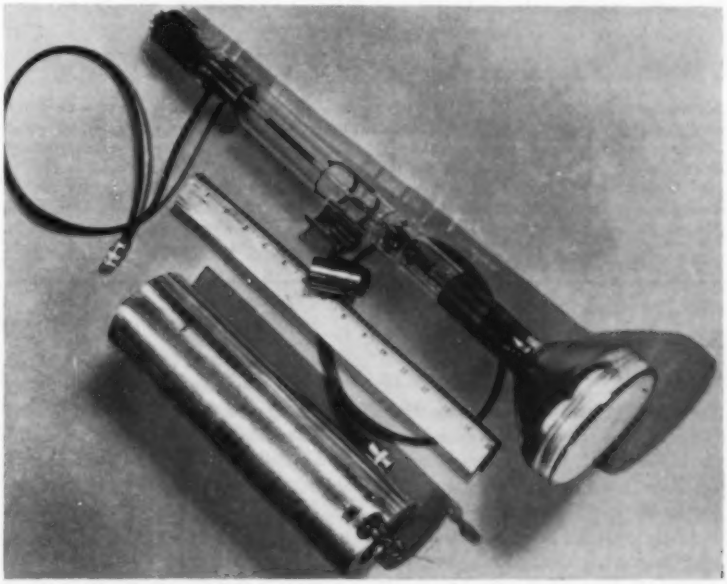
Its operation is based upon velocity-sorting the electrons which emerge from the end of the helix of the traveling wave tube section. A d-c beam of suitable voltage is passed down the helix. With an rf input, the beam interacts with the rf fields on the helix so that the beam is velocity and current modulated in accordance with the amplitude of the rf signals.

The velocity-modulated beam enters the region where the special electron-optical system is located. When a bias voltage is applied to an aperture in the electron-optical system, the electrons whose velocity is greater than the d-c velocity pass through the aperture and are allowed to impinge upon the screen of the cathode ray tube while the slower electrons are reflected.

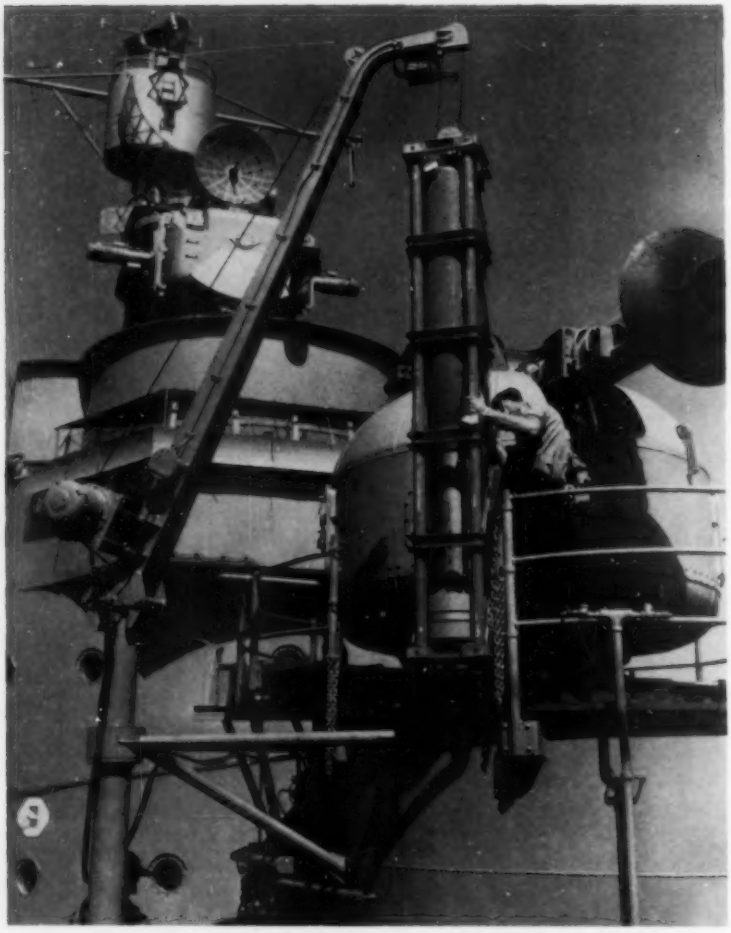
The big advantages of the tube are the reduction in the number of tubes and components since the one envelope provides amplification, detection, and display of radio frequency information. The elimination of the local oscillator, mixer, intermediate frequency amplifier, detector, and video amplifier, and their circuitry increases the equipment reliability.

The wide-band width of the tube permits the amplification, reproduction, and display of extremely short pulses, and the display of information contained in wide-band systems.

The project was sponsored by the Naval Research Laboratories.



Microwave signals go directly from the antenna into the tube, where they are amplified, detected, and displayed. Also shown is the solenoid which fits over the traveling wave tube section to focus it, and the tube's rf transducers. This wamoscope operates in the microwave frequency range of 2,000 to 4,000 megacycles.



Shown being loaded on a U. S. Navy destroyer is the new anti-submarine missile Able, a rapidly fired rocket. Fired from a special launcher which can be trained in almost a complete circle, the new weapon can be fired from a distance, and has a variable range. Total weight of the missile is 500 lb., with an explosive weight about equal to that of the conventional depth charge. One of the weapon's advantages is that attack can be initiated as soon as contact is established, and the launching ship does not have to be directly over the sub before the charge is dropped.

Satellite to Be Made of Magnesium

One of the most common questions asked about "Project Vanguard," or more commonly, the Earth Satellite has been, "Of what material will it be made?" The answer just came from Brooks and Perkins, a Detroit light metal fabricating company.

The satellite will be a sphere made of magnesium alloy (95 per cent magnesium, 3 to 3½ per cent aluminum and about 1 per cent zinc). Fabrication of two hemispheres to make up sphere will be by one-stroke deep draw, after heating the magnesium plate in gas to 600 or 700 F. Thickness of skin is 0.030 in. After drawing, the skin will be finished to four micro-in. and then polished to a mirror-like finish. The skin is not uniformly thick because of necessity of thicker areas at four antenna bosses.

Interior bracing of satellite is made of magnesium tubing and plastic (Kel-F), and the skin is screwed to interior bracing. Method of closure of two hemispheres is not precisely known, and will vary with type of instrumentation inside. It was thought that both hemispheres might have a bead worked on lip which would be melted down by torch to seal.

Total weight of satellite is 4 lbs and instrument package cannot weigh more or less than 17 lbs. The batteries used will be sealed and one of three different types; zinc-silver-oxide, zinc-mercury or indium-mercuric-oxide. There is not much hope for a solar type battery.

One of main troubles confronting the designers is to prevent the instrument package of the satellite from getting too cold. They plan on using transistors in radio transmitter, and these are subject to a relatively narrow range of temperatures. According to Brooks and Perkins, they are mounting a thermal switch in the instrument package to detect such cold temperatures. If the temperature drops the switch will open and allow heat gathered in the thin skin, to flow into the package. The switch will cut off if the heat gets too high.

NBS Studies High Pressures

To keep pace with the increasing use of high pressures, the National Bureau of Standards is studying instruments and standards that will measure pressures up to 200,000 psi. NBS is proceeding along several lines of development. One effort is on the development of piston gages for absolute measurement of pressures as high as 200,000 psi.

Other objectives under study are: (1) determination of a series of fixed points on the pressure scale; (2) establishment of standards for calibration of dynamic pressure measuring instruments; (3) investigation of the properties of working pressure gages such as those which utilize changes in electrical resistance with pressure; and (4) design and construction of mercury columns to serve as primary standards and for measuring differential pressures of of several atmospheres at total pressure up to 30,000 psi.

Increased accuracy of instruments are being sought by intercomparison of gages in the region of overlap and by refinement in the design of the piston gages.

COMING EVENTS

OCTOBER 8-12

38th National Metal Exposition and Congress, Public Auditorium, Cleveland, Ohio. To date 465 exhibitors are scheduled. All sessions of the Congress with its program of more than 150 papers will be held in the Hotels: Statler; Cleveland; Carter; and Hollenden. On Saturday, October 6th, and Sunday, October 7th, the ASM will hold its Pre-Metal Show Seminar in the Hotel Statler on "Creep and Recovery." 13 papers will be presented. Other highlights: a conference on Thorium Metal, October 11th, by the AEC and the ASM. There will be talks by 22 top men in this field. The American Welding Society, the Society for Non-Destructive Testing, and the Metal Div. of the American Institute of Mining, Metallurgical and Petroleum Engineers are co-sponsors of the Congress and each will present an extensive series of papers.

OCTOBER 15-17

National Association of Corrosion Engineers, Drake Hotel, Philadelphia, Pa. Symposiums on protective coatings, metals and alloys, cermets and plastics, and the use of statistical methods. Technical committee meetings will be held on the 15th.

OCTOBER 18-19

12th Annual National Conference on Industrial Hydraulics, Hotel Sherman, Chicago, Ill. Ten technical sessions will be devoted to discussions of the latest developments in fundamental and applied phases of industrial hydraulics in other fields. Hydraulic applications in atomic energy will be prominent among the subjects considered. Sponsors of the Conference are the Illinois Institute of Technology and its affiliate, Armour Research Foundation.

OCTOBER 22-24

National Lubricating Grease Institute, Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

OCTOBER 23

The Society of Plastics Engineers, Upper Midwest Section, Curtis Hotel, Minneapolis, Minn. The regional conference will be an Isocyanate Symposium. Titles of papers are: New Surface Coatings based upon Diisocyanates; Urethane Coatings and Adhesives; Non-Scorching Polyurethane; Effects of Foaming Catalysts on Hydrolysis Aging of Urethane Foams; Use and Applications of Isocyanate Foams.

OCTOBER 22-25

11th Annual Protective Packaging and Materials Handling Exposition and Competition, Kiel Auditorium, St. Louis, Mo. Sponsored by the engineers of the above group, it will include a four-day technical short course of 26 sessions ranging in subject matter from elementary reviews of materials, equipment and methods, to human relations. The course will be presented under the direction of Stephen W. Vasquez, Dean of the School of Commerce and Finance, at St. Louis University.

OCTOBER 28-31

Semi-annual Meeting of the American Gear Manufacturers Association, The Edgewater Beach Hotel, Chicago, Ill. For further information write: John C. Sears, Executive Secretary, One Thomas Circle, Washington 5, D. C.

OCTOBER 30-NOVEMBER 1

Fall Meeting, National Fluid Power Association, Hotel Cleveland, Cleveland, Ohio. For further information write to the Association's Headquarters at 1618 Orrington Ave., Evanston, Ill.

OCTOBER 31-NOVEMBER 2

1956 Annual Meeting and Exhibit, Society for Experimental Stress Analysis, Deshler-Hilton Hotel, Columbus 1, Ohio. For further information write to: Dr. W. M. Murray, P.O. Box 160, Cambridge 39, Mass.

NOVEMBER 2-3

6th Annual Tool Engineering Conference, Illinois Institute of Technology, 35 West 33rd St., Chicago 16, Ill. Theme of conference is "New Horizons in Industry." Dr. Harry Osborn, technical director of the Tocco Div., of Ohio Crankshaft Co., Cleveland, will present management's viewpoint, and P. L. Siemiller, Vice-Pres., International Association of Machinists, will speak for labor. The kick-off session will be at 8:00 p.m. with the November 3rd program consisting of panel discussions on New Cutting Tool Materials; Economic Analysis in Machine Tool and Equipment Replacement; New Developments in Extrusion Methods; and Automation in the Metal Working Industry.

NOVEMBER 15-16

National Association of Corrosion Engineers, Hotel Statler, Detroit, Mich. Symposia on the automotive, construction, chemical, utilities and power industries.

NOVEMBER 25-30

ASME Annual Meeting, Hotel Statler, New York City.

NOVEMBER 26-30

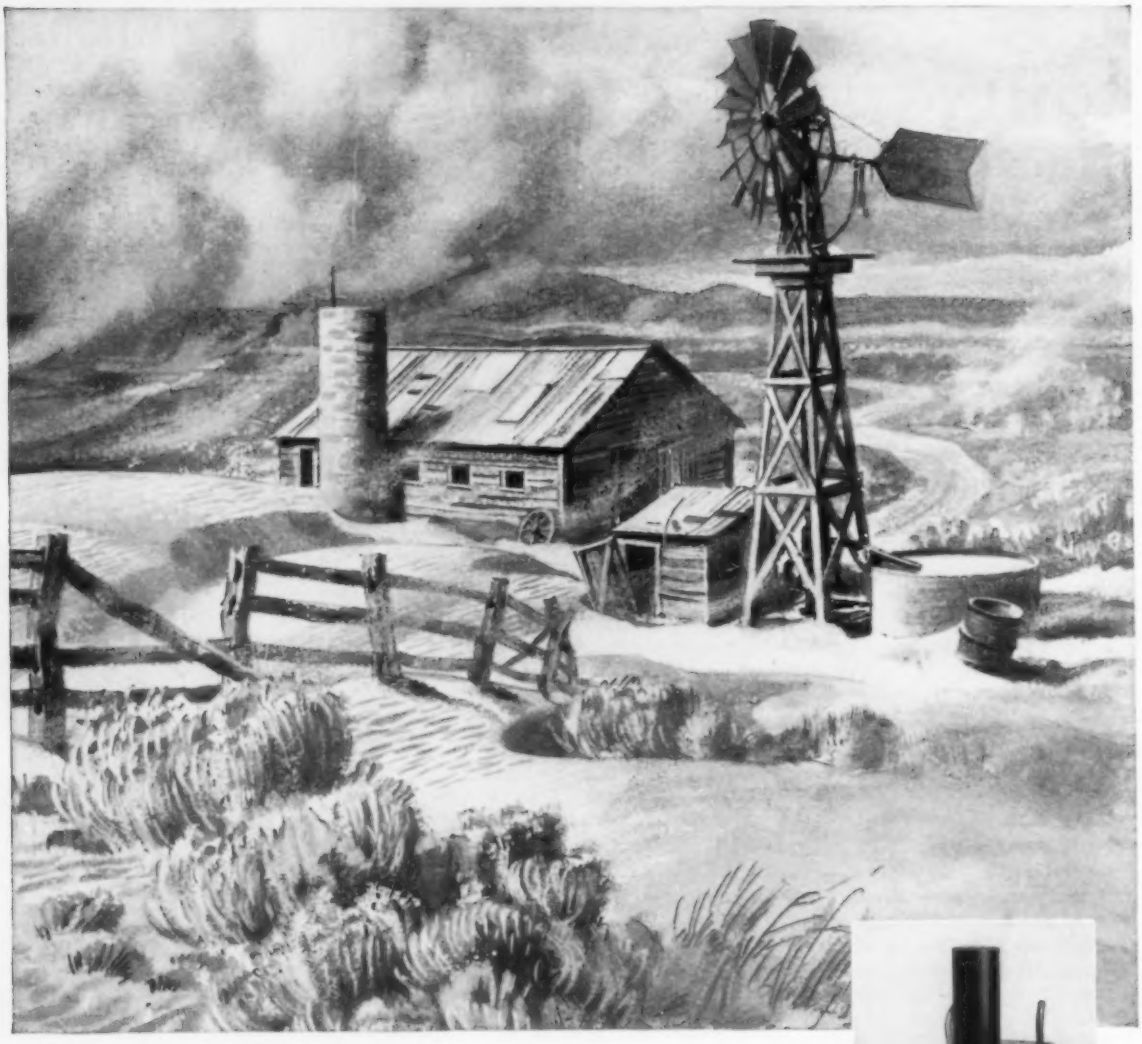
22nd National Exposition of Power and Mechanical Engineering, Coliseum, New York City. During the week will be the 76th annual meeting of the ASME, including sessions of the Society's Nuclear Engineering Div. The 35th annual Atomic Energy in Industry Conference of the National Industrial Conference Board will also be held at that week.

NOVEMBER 26-30

3rd International Automation Exposition, New York Trade Show Bldg., 500 8th Ave., New York City. There will be 180 exhibiting manufacturers and 60 lecture-demonstration clinics on computers, process automation, machine automation, servomechanisms, electromechanical and electronic components.

DECEMBER 10-12

1956 Eastern Joint Computer Conference, Hotel New Yorker, New York City. The meeting will be jointly sponsored by the IRE, AIEE, and the Association for computing Machinery. The theme will be "New Developments in Computers." Besides an extensive program of technical papers, there will be many exhibits by manufacturers in the computing field.



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Adlake mercury relays

Adlake relays require no maintenance whatever...are quiet and chatterless...free from explosion hazard. Dust, dirt, moisture and temperature changes can't affect their operation. Mercury-to-mercury contact gives ideal snap action, with no burning, pitting or sticking. Time delay characteristics are fixed and non-adjustable.

For more information about Adlake Relays, write The Adams & Westlake Company, 1169 N. Michigan, Elkhart, Indiana

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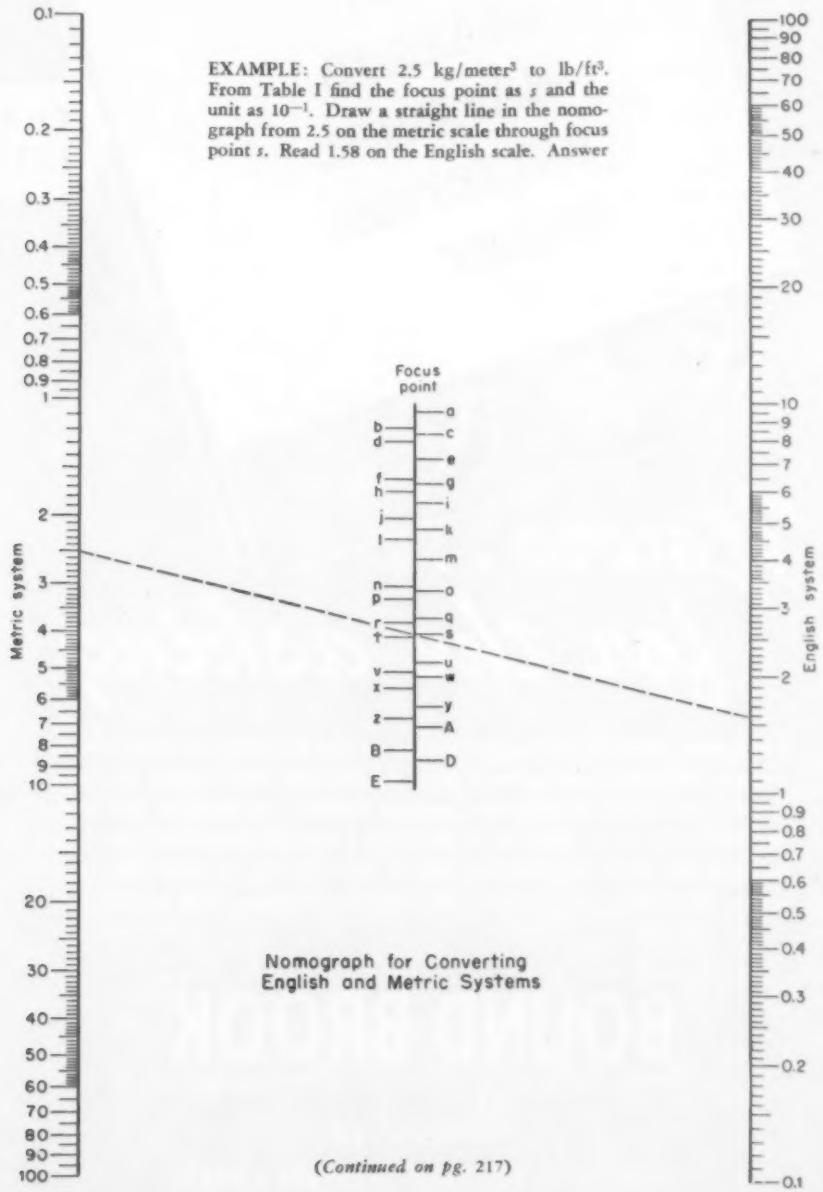
Conversions in English and Metric Systems

H. A. MAGNUS
Talco Engineering Company

CONVERTING FROM ONE SYSTEM OF UNITS TO ANOTHER is a burdensome task—especially units such as: kg-calories/min to ft/sec². Even with tables to facilitate the conversion, a slide-rule calculation is still required to multiply the correct units with the previous ones.

The nomograph and tables on the following page can be used to convert entire units directly from one system to the other within normal slide-rule error.

EXAMPLE: Convert 2.5 kg/meter³ to lb/ft³. From Table I find the focus point as *s* and the unit as 10^{-1}. Draw a straight line in the nomograph from 2.5 on the metric scale through focus point *s*. Read 1.58 on the English scale. Answer



Nomograph for Converting English and Metric Systems

(*Continued on pg. 217*)

Yours.. for the asking

The proper material for sintered bronze or iron bearings has always been a major problem to design men. Now for the first time a chart has been engineered, clearly showing the complete chemical, mechanical, and work characteristics of a wide range of sintered bearing materials. The best material for most applications can be selected by a draftsman in a matter of minutes. Only requests on company stationary will be honored.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

PRODUCT ENGINEERING - REFERENCE BOOK SHEET

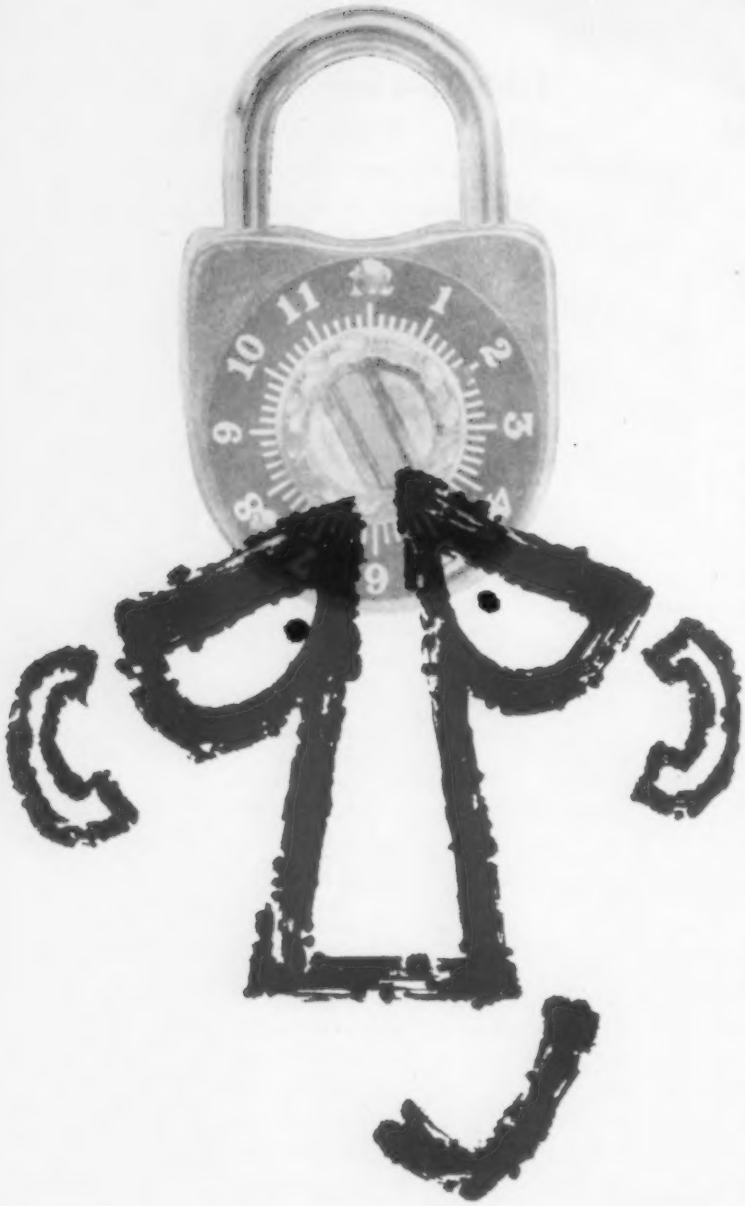
Conversions in English and Metric Systems (continued from page 215)

Table I—Conversions from Metric to English

From Metric	To English	Focus	Units
centimeters (cm)	in.	v	1
cm-dyne	lb-ft	q	10^{-7}
cm-gram	lb-ft	b	10^{-5}
cm of mercury	lb/in.^{2}	l	10^{-1}
cm/sec	ft/sec	x	10^{-1}
cm/sec^2	ft/sec^2	x	10^{-1}
cm^2	in.^{2}	m	10^{-1}
cm^3	ft^3	h	10^{-5}
cm^3	in.^{3}	t	10^{-1}
cm^3	gallons	y	10^{-3}
kilograms (kg)	poundals	r	10^3
kg	lb	k	1
kg calories	B.T.U.	f	1
kg calories	ft-lb	i	10^3
kg calories	hp-hr	B	10^{-3}
kg calories/min	ft-lb/sec	e	10
kg calories/min	hp	p	10^{-1}
kg-cm^2	lb-ft^2	z	10^{-4}
kg-meter	ft-lb	b	1
kg/meter	lb/ft	c	10^{-1}
kg/meter^2	lb/ft^2	A	1
kg/meter^2	lb/in.^{2}	D	10^{-2}
kg/meter^3	lb/ft^3	s	10^{-1}
kilometer (km)	ft	x	10^4
km	miles	d	10^{-1}
km	ft	x	10^4
km	yards	n	10^4
km/hr	miles/hr	d	10^{-1}
km/hr/sec	ft/sec^2	a	10^{-1}
km/hr/sec	miles/hr/sec	d	10^{-1}
km^2	ft^2	E	10^7
km^2	square miles	g	10^{-1}
liters	ft^3	h	10^{-2}
liters	in.^{3}	t	10^3
liters	quarts	o	1
liters	gallons	y	1
liters/min	gallons/sec	u	10^{-2}
meters	ft	x	10
meters	in.	v	10^3
meters	yards	n	1
meters-kg	lb-ft	b	1
meters/min	miles/hr	w	10^{-1}
meters/sec	ft/sec	x	10
meters/sec^2	ft/sec^2	x	10
meters^2	acres	j	10^{-4}
meters^2	ft^2	E	10^2
millimeters	in.	v	10^{-1}
millimeters^2	in.^{2}	m	10^{-3}

Table II—Conversions from English to Metric

From English	To Metric	Focus	Units
in.	centimeters (cm)	v	1
in.	millimeters	v	10
in.^{2}	cm^2	m	10
in.^{2}	millimeters^2	m	10^3
in.^{3}	cm^3	t	10
in.^{3}	liters	t	10^{-2}
in./sec	cm/sec	v	1
in./sec^2	cm/sec^2	v	1
ft	kilometers (km)	x	10^{-4}
ft	meters	x	10^{-1}
ft^2	km^2	E	10^{-7}
ft^2	meters^2	E	10^{-5}
ft/sec	meters/sec	x	10^{-1}
ft^3	cm^3	h	10^5
ft^3	liters	h	10^2
ft/sec^2	cm/sec^2	x	10
ft/sec^2	km/hr/sec	a	10
ft/sec^2	meters/sec^2	x	10^{-1}
ft-lb	cm-dynes	q	10^7
ft-lb	cm-grams	b	10^5
ft-lb	kg-calories	i	10^{-3}
ft-lb	kg-meters	b	1
ft-lb/sec	kg-calories/min	e	10^{-1}
miles	km	d	10
miles^2	km^2	g	10
miles/hr	meters/min	w	10
miles/hr	km/hr	d	10
miles/hr/sec	km/hr/sec	d	10
yards	km	n	10^{-4}
yards	meters	n	1
lb	kilograms	k	1
lb-ft	cm-dynes	q	10^7
lb-ft	cm-grams	b	10^5
lb/ft	kg/meter	c	10
lb/ft^3	kg/meter^3	s	10
lb/ft^3	kg/cm^3	z	10^2
lb/ft^2	kg/meter^2	A	1
lb/in.^{2}	cm of mercury	l	10
lb/in.^{2}	kg/meter^2	D	10^2
poundals	kilograms	r	10^{-2}
quarts	liters	o	1
gallons	cm^3	y	10^3
gallons	liters	y	1
gallons/sec	liters/min	u	10^2
horsepower (hp)	kg-calories/min	p	10
hp-hr	kg-calories	B	10^2
B.T.U.	kg-calories	f	1
acres	meters^2	j	10^4



keeping an idea locked between your ears?

If that idea deals with the Guided Missile field, you'll find that Firestone has the key to unlock it—and open the door to a happier future for you. Firestone's creative climate and tangible rewards keep that door open to a steady flow of achievement.

Since the turn of the century, Firestone has built its phenomenal progress on men with ideas. Currently, Firestone is carrying forward the Army's vital program for the "Corporal," first surface-to-surface ballistic guided missile. This involves engineering, field test and service, and missile and component development.

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Flight Simulation
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Force-Speed-Horsepower Nomograph

LEO FIDERER

Design Engineer, Huck Co., New York, N. Y.

This nomograph contains all pertinent values relating to force, speed, torque and horsepower. It can be used to select gears, belts, chain drives, and rotating machine components, and is based on the following equations:

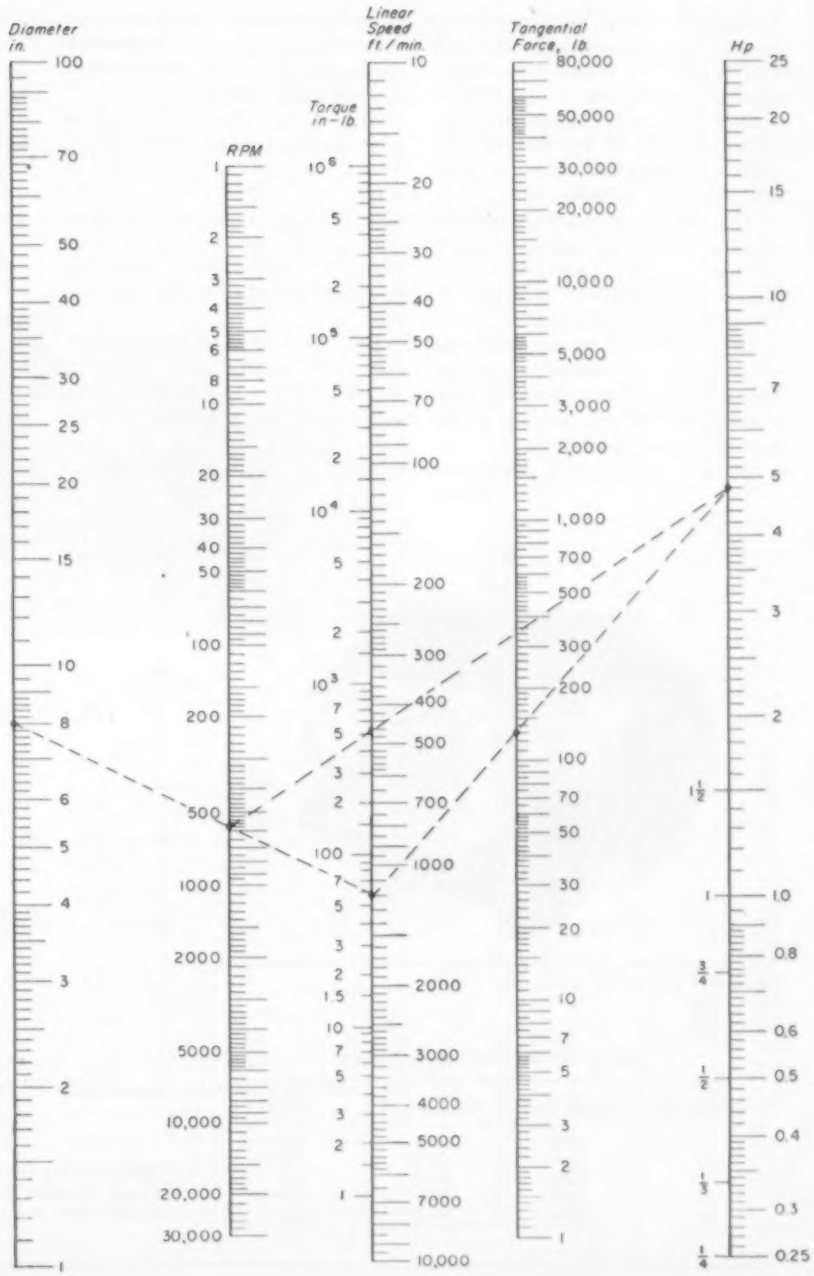
$$V = 3.14DN/12$$
$$T = 63{,}000P/N$$
$$P = VF/33{,}000$$
$$T = 3.14DF/2$$

where
V = linear velocity, ft/min
D = diameter, in.
N = rotational speed, rpm
P = power, hp.
T = torque, in-lb
F = tangential force, lb

Straight line through any two values used in one of these equations will intersect the corresponding third value on the proper scale.

Example:
Permissible tooth load on a gear with an 8 in. pitch dia is 130 lb at a maximum pitch line velocity of 1200 ft/min. (A) What is the maximum hp transmitted by the gear. (B) At what speed and torque will the shaft develop max hp.

Solution:
(A) Line through 130 lb and 1200 ft/min gives 4.75 hp. (B) Line through 8 dia and 1200 ft/min gives 575 rpm. Line through 575 rpm and 4.75 hp gives 520 in.-lbs. The torque can also be obtained by a line through 8 in. dia and 130 lb tangential force.



Single-Phase Motors

Start on Low Current

Starting current requirements are said to have been reduced as much as 40 per cent in a line of five single-phase, capacitor-start, capacitor-run motors. They were designed in ratings of 7½ through 20 hp, for rural applications where low starting currents are demanded by power companies.

The addition of running capacitors permits use of the starting winding for running. The starting current of the auxiliary winding has been removed from the contacts of the centrifugal switch and an industrial-type contactor has been added to open the circuit. All auxiliary equipment has been placed on the outside of the motors in weatherproof covers.

Through the use of a running capacitor, the auxiliary winding is able to contribute a share of the power to the motor. This adds what amounts to an auxiliary phase.

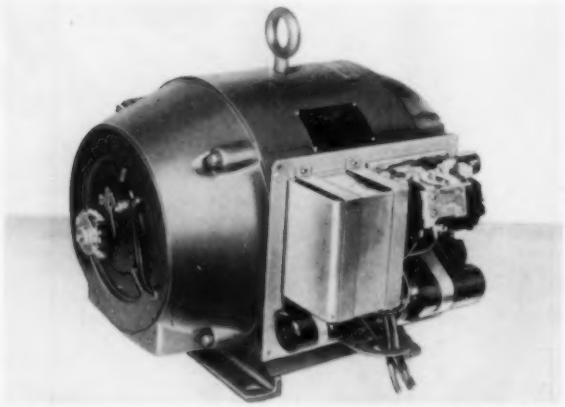
As a result, the frame sizes for given horsepowers has been reduced. The 10 and 15 hp motors, for example, use NEMA frames 324 and 326. In addition, the running operation of the motors approaches a polyphase type in smoothness and efficiency, according to the manufacturer.

Since the industrial-type contactor opens the circuit, the centrifugal switch is needed only to control the small current of the solenoid or holding coil of the main contactor. This helps reduce the heavy toll formerly exacted of centrifugal switch contacts when they bore the heavy starting current of the auxiliary winding.

The cushioner starting effect is accomplished by energizing only the auxiliary start winding and one-half the main winding when the motors are thrown across the line. At about two-thirds of full load speed, the centrifugal switch actuates a set of contactors which removes the starting capacitors from the circuit and connects the other half of the main winding. The cushioned start also reduces starting torque values.

The result is substantially reduced starting current requirements. For example, the 20 hp, 1800 rpm motor requires a starting current of 228 amp at 220 v. This compares favorably with the starting current of a 7½ hp single-phase motor when started across the line.

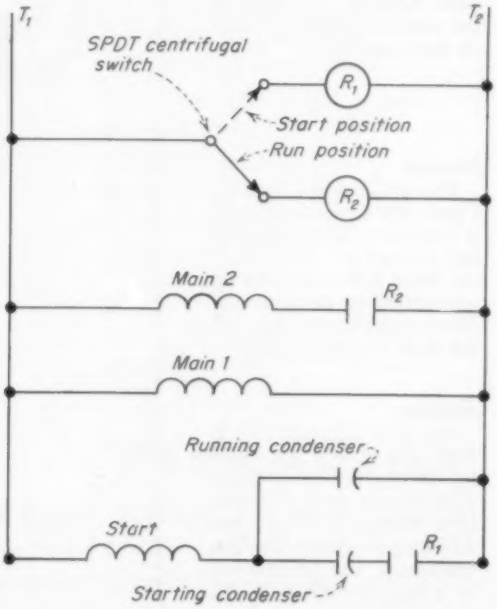
Starting sequence of this motor is as follows: when power is applied to



Weatherproof covers have been removed to show how all auxiliary equipment is mounted externally.

Starting Current and Torque Values

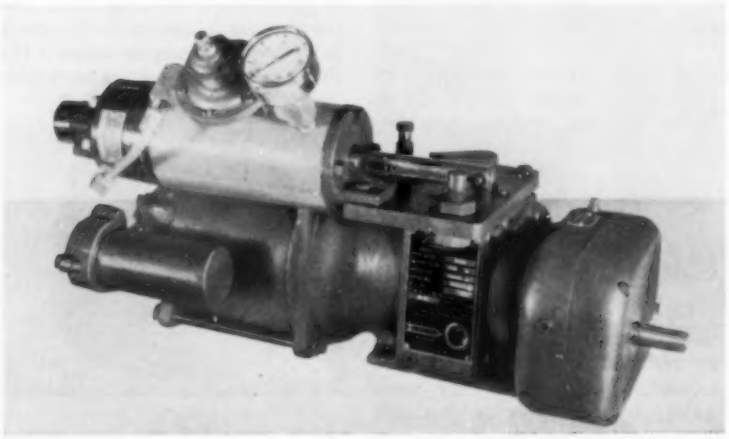
Horsepower	Speed, rpm	Torque, lb-ft	Current, amp (220 v)
7½	1200	45.3	102
10	1800	44.0	148
	1200	60.1	130
15	1800	68.0	214
20	1800	69.0	228



Main winding of the new single-phase motor is a two-circuit arrangement. Centrifugal switch is single-pole, double-throw and carries only relay coil current.

the motor terminals, the centrifugal switch is in the start position and permits relay R_1 to be energized (see accompanying circuit drawing). Contacts R_1 close, throwing the start condenser across the line and in series with the start winding. Main-1 is across the line at all times. When the motor attains switching speed, the centrifugal switch opens the line to R_1 and throws relay coil R_2 across the line. With R_1 de-energized, the starting condensers are cut out of the circuit. Contacts R_2 are closed throwing Main-2 in parallel with Main-1 and the motor now operates with full main winding. Robbins & Myers, Inc., Springfield 99, Ohio.

For more information—
Circle 1, inside back cover



Speed Control for Fhp Drives

An air control system for fhp variable speed drives can be used on units delivering speeds from any desired maximum down to zero and, if desired, reverse. High accuracy setting and maintenance of speed over the entire range is claimed. Linear speed vs pressure characteristic is standard with most models but square root function and other characteristics can be had.

The pneumatic control operates on a 3 to 15 psi signal, with signal originating from liquid level, pressure or flow rate devices or some other type of transducers. The control signal may also be transmitted from any one of the leading makes of pneumatic recorders or recorder controllers.

Normally zero speed is obtained at a control pressure of 3 psi, with maximum speed at 15 psi. However, the control can be installed to produce zero or any other speed at 15 psi.

The transmission is available with a wide variety of built-in reducers, including spur and worm reduction types with output shaft horizontal or vertical. Built-in motors of all types can be furnished or the drive may be coupled or belt-connected to the driving means. Larger units, up to 3 hp, are also available with similar air controls. Graham Transmissions Inc., Menomonee Falls, Wis.

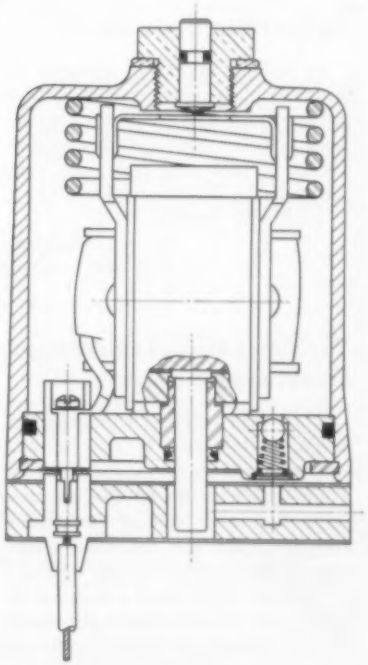
For more information—
Circle 2, inside back cover

Oil-Immersed Solenoid

The solenoid in its die-cast, sealed case is only slightly larger than a standard model of same rating when enclosed in a dust-tight cover. The sealed unit is equipped with plug-in contacts. It is said to be installed as easily and quickly as a radio tube. The unit is anchored in working position by four captive bolts. Manual operation of the solenoid for machine set-up and other such purposes is accomplished by means of a sealed pin in the case top.

The new solenoid is built to JIC specifications. It is fully shock-mounted in two directions and is reported to operate 35 to 50 F cooler than standard models. It is currently being made in three models, of 5, 7 and 8 lb push force, respectively, $\frac{5}{16}$ in. stroke. Dimensions for all three are about $2\frac{3}{4}$ x $2\frac{3}{4}$ x $4\frac{1}{2}$ in. long.

A typical test solenoid showed no



CONTINUED ON PAGE 222

measurable wear after 8.5 million strokes at 24 strokes per min. Another test case showed only superficial wear on the beating surfaces after 34 million strokes at 300 strokes per min. Detroit Coil Co., 2435 Hilton Road, Ferndale, Mich.

For more information—
Circle 3, inside back cover

Epoxy Resin Preforms for Bonding

Epoxy resin preforms are available for bonding by thermal setting without the application of pressure to the pieces joined. The material is a natural or amber-colored powder at room temperature. It is fluid at 248 to 302 F. A self-contained catalyst is said to make possible a preform in almost any desired shape.

The resin will bond, join and pot metal-to-metal, metal-to-non-metals, non-metals to non-metals. Atlas EE Corp., 47 Prospect St., Woburn, Mass.

For more information—
Circle 4, inside back cover

Striped Rigidized Metal

By rolling in bands separated by bands of plain metal, striped patterns are produced, in stainless steel, aluminum or other metals. Other arrangements of patterned and plain areas are available. Rigidized Metals Corp., 673 Ohio St., Buffalo, N. Y.

For more information—
Circle 5, inside back cover

Weldable High Temperature Strain Gage

This strain gage has a dynamic test range to 1600 F. It can be spot welded on flat or curved surfaces. Field tests have shown that in most cases the spot welding installation does not cause any significant alteration of the structure being tested.

Available gages have a nominal resistance of 120 ohm and a gage factor of 1.80. Length and width dimensions

of the two available gage types are 1.250 x 0.125 in. and 0.750 x .250 in. Micro-Test, Inc., 657 N. Spaulding Ave., Los Angeles 36, Calif.

For more information—
Circle 6, inside back cover

Elastomer Coated Fabrics

Kel-F elastomer-coated fabrics made in regular production quantities are available. Nylon fabric has been successfully coated and the same coating is currently being developed for glass and Dacron fabrics. The upper temperature limit of the nylon coated with Kel-F is 200 F, due to the limitations of the fabric. The coated Dacron will have a high temperature limit of 400 F and coated glass fabric will be good to 480F for short periods, 400 F for extended periods. A sample of elastomer-coated nylon cooled from 20 F to −85 F over a 4 hr period showed some change in flexibility, but no signs of cracking in the 180 deg bend test. Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

For more information—
Circle 7, inside back cover

Heat Reflective Laminate

This laminate is said to provide a barrier to heat transfer at temperatures up to 1200 F. It is composed of glass fabric, silicone resin binders, combinations of highly reflective metalized surfaces, and inert substances for added resistance to surface corrosion. Swedlow Plastics Co., 6986 Bandini Blvd., Los Angeles 22, Calif.

For more information—
Circle 8, inside back cover

Toggle Action Clutch

Disengagement speed is said to be approximately 400 to 500 rpm lower than engagement speed. The wide differential allows the engine to idle at a satisfactory speed without slippage at relatively low operating speeds, and provides for a greater load capacity in proportion to clutch weight. The clutch is available for use on a wide

variety of gasoline and diesel engines in the 10 to 50 hp range. Salsbury Corp., 1161 E. Florence Ave., Los Angeles 1, Calif.

For more information—
Circle 9, inside back cover

Silicone Foam Rubber

This foam rubber is said to remain soft and resilient over a temperature range of −100 F to 480 F. Because of its interconnecting cell structure, silicone foam recovers shape instantly after being compressed for long periods at elevated temperatures. Typical of silicone, this foam is inert in ozone and weathering, is non-sticking, non-corrosive, odorless, tasteless and exhibits excellent electrical properties.

Initially, the foam material will be offered in sheet form and custom mold-

CONTINUED ON PAGE 224

Using

DU PONT ELASTOMERS

NEOPRENE · HYPALON®

in Design

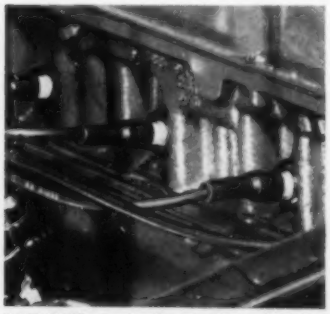
Molded spark-plug boots of HYPALON® withstand ozone and heat (270°F.)

Several years ago a leading car manufacturer set out to find a new rubber material for its spark-plug boots. New designs had increased engine horsepower but at the same time reduced engine space, thus increasing the temperature under the hood. Existing boots couldn't take the punishment of temperatures averaging 270°F. with occasional peaks of 340°F., or the increased ozone concentration caused by reduced space under the hood.

After testing several resilient materials, they decided on Du Pont HYPALON synthetic rubber. HYPALON has exceptional resistance to deterioration at high temperatures and it is virtually ozone-proof. The problem was solved. HYPALON has been specified for the spark-plug boots on this manufacturer's new V-8 and six-cylinder engines.

HYPALON also offers outstanding resistance to weather and oxidizing chemicals. And it can be compounded in an unlimited range of sunlight-stable colors.

Why not investigate the possibilities of using HYPALON in your designs? We'll be glad to send you complete property data and application information. If you have a specific problem, please let us know.



HYPALON spark-plug boots resist high ozone concentrations and temperatures averaging 270°F., in the engine of one of today's leading cars.

Why Remington uses NEOPRENE on its new model stud driver

Powerful and fast, the new Remington "MIGHTY-MITE" stud driver uses a 22-caliber cartridge to drive ¼" studs in steel or concrete without pre-drilling.

The "MIGHTY-MITE'S" barrel must be twisted and held firmly against the work to expose the firing pin. Neoprene traction grip stands up to grease, oil and perspiration.

Neoprene resists grease, oil and perspiration, assures a firm tool grip

Small contractors and "do-it-yourselfers" are finding the new Remington "MIGHTY-MITE" a handy tool for driving ¼" studs into steel or concrete. Just a hammer tap fires the 22 caliber cartridge, which drives the stud, anchoring wood or steel fixtures in seconds—without pre-drilling.

Design features of Remington's "MIGHTY-MITE" are simplicity and safety. The barrel of the tool must be twisted, then thrust down and held firmly against the work to expose the firing pin. Neoprene was selected for the barrel traction grip because of its resistance to the effects of grease, oil and perspiration. A green neoprene compound was selected because it enhanced the appearance of the finished product.

This is just one application where neoprene has proved its effectiveness. If you need a resilient material with exceptional resistance to oils, greases, solvents, chemicals, abrasion and flex cracking, it will pay you to investigate neoprene. We'll be glad to send you further information —data on properties and proven applications. If you have a specific problem, please let us know.

DU PONT

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HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

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☐ I am particularly interested in_____

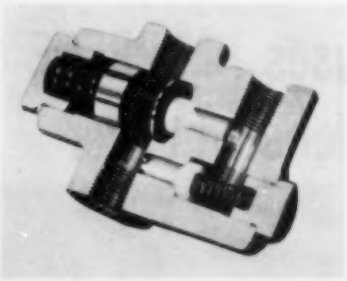
☐ Please add my name to the mailing list for your free publications, "The Neoprene Notebook" and "Facts about HYPALON."

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. PE-10
Wilmington 98, Delaware

*Name*_____
*Firm*_____
*Address*_____
*City*_____ *State*_____

ings up to 8 in. thick. Connecticut Hard Rubber Co., 407 East St., New Haven, Conn.

For more information—
Circle 10, inside back cover



Hydraulic Lock Valve

This valve is said to be applicable to virtually any hydraulic lift system. It supplements the seal on a standard directional valve, to provide a positive lock of the cylinder until the flow is deliberately reversed. The valve can handle up to 20 gpm and will operate satisfactorily up to 1500 psi.

The lock valve has two units, check and relief. Poppets on the check valve (which is held in position by a light spring) and on the relief valve are constructed of nylon. Webster Electric Co., Racine, Wis.

For more information—
Circle 11, inside back cover

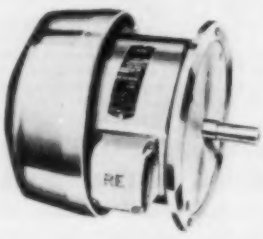
Switch with Adjustable Activating Lever

The switch's operating position is adjustable between 0.670 and 0.880 in. Operating position is controlled by means of an adjustment screw without removing the switch from its mounting. The switch is said to be suited for timers, computers or other multi-mounted switch devices.

It is available in either straight or formed lever designs, and either with or without a roller. A choice of solder type or screw terminals is available, as well as a wide selection of preset operating characteristics. Contact arrangement is single-pole, double-throw. The switch can also be supplied with split-contact double-throw circuitry.

Characteristics are as follows: operating force, 2¼ oz max; release force, ½ oz min; overtravel, 0.460 in. max., and differential travel, 0.007 to 0.50 in. All models of the switch are UL-listed, at 15 amp, 125, 250 or 460 v a-c; ½ amp, 125 v dc; ¼ amp, 250 v d-c. Micro Switch, Freeport, Ill.

For more information—
Circle 12, inside back cover



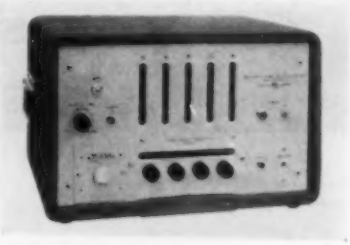
Electric Motors for Machine Tools

These motors are of radial air gap design, and use a thinner, light-weight, low-inertia rotor. Motors are available in ratings from ½ through 3 hp, continuous or intermittent duty. Reuland Electric Co., Alhambra, Calif.

For more information—
Circle 13, inside back cover

Computing Indicator

Precise measurements of speed, pressure, thickness and numerous other quantities can now be read directly in the desired units without time-consuming conversion calculatons. An electronic counter with variable gate time functions as a multiplier of the transducer input to provide direct readings. Gate time may also be selected manually and is adjustable from 0.0001 to 0.9999, in 0.0001 sec increments. Dynac, Inc., 395 Page Mill Road, Palo Alto, Calif.



For more information—
Circle 14, inside back cover

High Force Liquid Spring

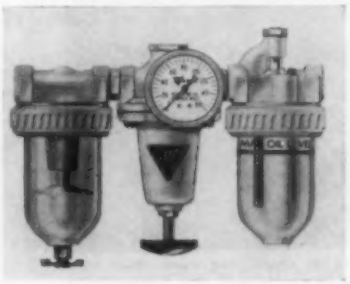
This spring is ¾ x 2½ in. long, plus mounting stud. It has a $\frac{5}{32}$ in. stroke with a 800 lb preload and an end force of 4000 lb. Taylor Devices Inc., 188 Main St., N. Tonawanda, N. Y.

For more information—
Circle 15, inside back cover

Automatic Air Line Control and Maintenance

A line of filters, lubricators and regulators for air-operated devices is available in various combinations. They can be arranged to remove foreign matter and condensation, provide oil-fog lubrication and control air line pressure.

The filtering unit has a porous



CONTINUED ON PAGE 226

NEW KAYDON THIN-SHELL NEEDLE BEARINGS

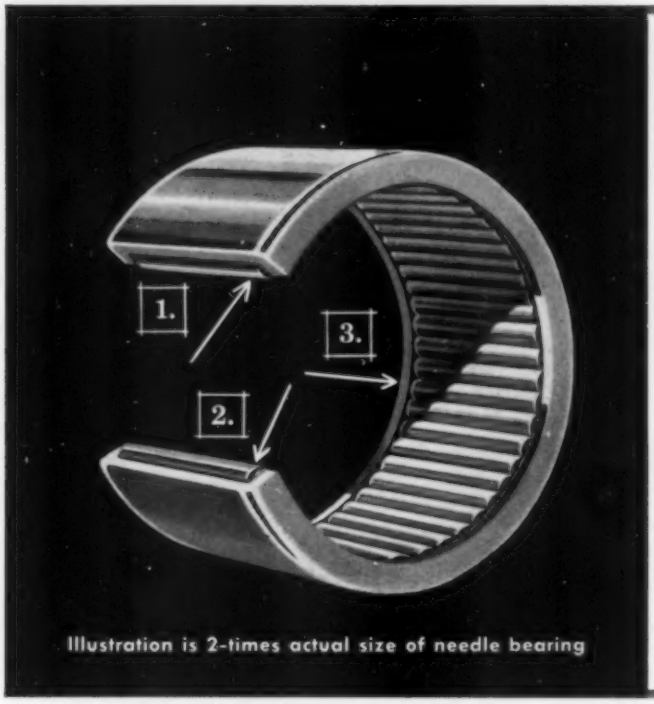
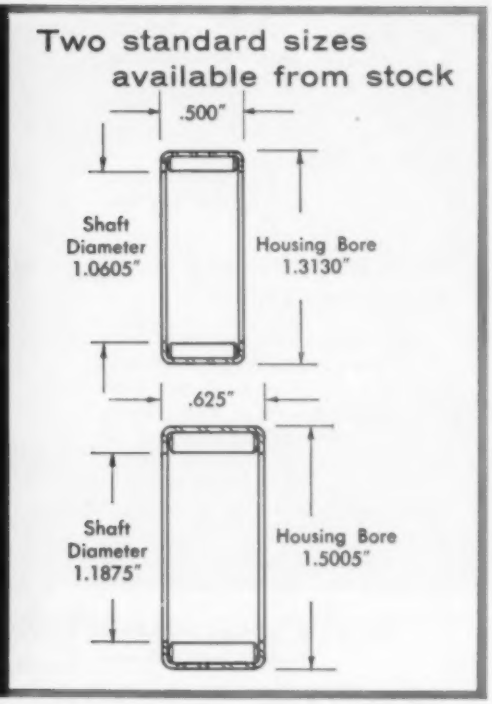


Illustration is 2-times actual size of needle bearing



You get these Kaydon design advantages:

1. **Greater effective length needle rollers for MORE CAPACITY (41% on ½" width)... LONGER LIFE (2.8 times as much on ½" width)**
2. **Simplified construction that SAVES you money**
3. **Pre-packed lubrication that SAVES assembly time**

HERE it is! Kaydon's new thin-shell needle bearing. A bearing that gives you more of everything — more capacity... more economy... *plus longer life* than any other comparable bearing, because of greater effective length of spherical end rollers.

This new bearing is ready for you right now from stock in two standard sizes (illustrated). Other sizes will be available later.

For complete specifications, ask for Data Sheet No. K562—write, call or wire Kaydon of Muskegon.

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 124" outside diameter... Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

bronze filter element, available in three degrees of filtration, 20, 40 and 90 microns. The units are for pressures up to 150 psi and up to 120 F. Available in ¼, ⅜ and ½ in. female pipe connection sizes.

The lubricator is for pressures as high as 150 psi, 120 f. Available in ¼, ⅜ and ½ in. sizes. Air regulators, ⅛ through ½ in., are available with two, three and four-way connections. Watts Regulator Co., 10 Embankment St., Lawrence, Mass.

For more information—
Circle 16, inside back cover

Timer Keeps Running After Power Failure

This instrument's movement runs electrically or mechanically and consists of a synchronous electric time unit combined with a spring-driven time unit which is held in reserve. If electricity should fail, the spring driven unit goes into action instantly. Upon power resumption or circuit repairs, the synchronous electric motor again takes over. Industrial Timer Instruments Co., 189 W. Madison St., Chicago 2, Ill.

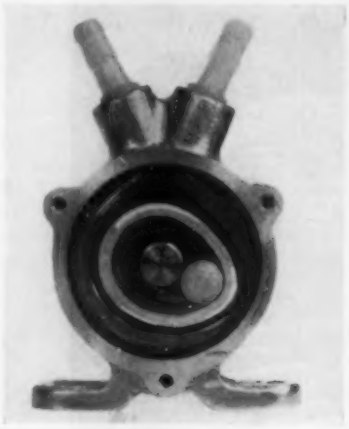
For more information—
Circle 17, inside back cover

Palm Button Valve

A leakproof palm button valve is suitable for applications which require a normally closed straight-way or three-way hand-operated pilot valve. This valve can be provided with a tumbler type lock, enabling the valve to be locked by authorized personnel in either the open or closed position.

Overall height is 2⅜ in. and both straight-way and three-way have a ¼ in. dia flow capacity. Ross Operating Valve Co., 134 E. Golden Gate Ave., Detroit 3, Mich.

For more information—
Circle 18, inside back cover



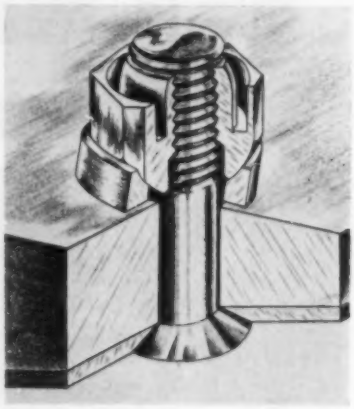
Pump Kneads Fluid Through Tubing

Inside the aluminum body of this pump a nylon roller follows a planetary action around the driven shaft, kneading a loop of vinyl tubing. This forces viscous fluids, slurries, gases through the tubing, pumping up to 19 oz of water per min at 1500 rpm. The pump requires 1/25 hp to operate, measures 2⅛ x 2⅛ x 3½ in. high and weighs ½ lb. Becher Pump Co., 852 Belmont Ave., Chicago 14, Ill.

For more information—
Circle 19, inside back cover

Self-Aligning Locknut

For fastening applications involving non-parallel surfaces, a line of counterbored, self-aligning, hexagon locknuts has been designed. The nut, varying the ball joint principle, has a base with a convex seat which mates with an alloy steel concave seat washer. The nut tilts 8 deg in any direction from centerline to compensate for angular misalignment of fastening surfaces. Tightening the bolt in the normal manner automatically seats the nut



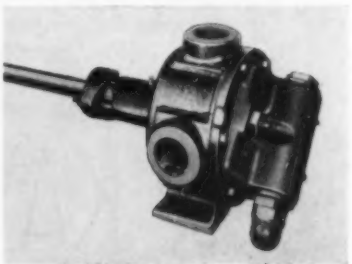
in the base and adjusts it to the proper angle.

Nut parts are adaptable to either short or long thread bolts by the incorporation of a counterbore in the nuts. In addition to reducing the bolt thread length requirement, the counterbore and washer base reduce the possibility of threads in bearing. Thread sizes currently designed for the self-aligning locknut are 10-32, ¼-28 and ⅜-24. Elastic Stop Nut Corp. of America, Union, N. J.

For more information—
Circle 20, inside back cover

Gear Rotary Pumps

This pump's circular tooth design in the rotors and idlers is said to provide rolling contact and smoother engagement of teeth, resulting in a reduction of friction and a high volumetric efficiency. The series consists of 10 basic sizes, from 3 to over 100 gpm, in two speed ranges up to maximums of 650 and 1800 rpm. The group is designed to handle liquids



CONTINUED ON PAGE 228

The Engineer from Continental Screw Co. ...

. . . guarantees you 24-hour service on all 17 types of self-tapping screws

Having trouble getting deliveries?
Talk to the Engineer from Continental

Continental offers you the largest inventory of tapping screws in the country. And this is backed by the most complete line of tapping screws. Only Continental makes all 17 types of thread-forming and thread-cutting screws. It is part of their 2,118,000 screw styles and sizes available for 24-hour delivery.

This vast inventory, combined with Continental's top position in the design and production of special fasteners, guarantees you faster service and a top-quality product.

It will pay you to discuss your needs with **Continental.** Their design engineers and production specialists offer you the benefits of over 50 years experience and know-how.

Only Continental Engineers
Are Required To Have This Training

Each engineer at Continental is required to undergo thorough experience producing ground thread taps and gages, with their exacting screw thread dimensions. This special training is passed on to you—at no extra cost.

CONTINENTAL SCREW COMPANY INC. 1904

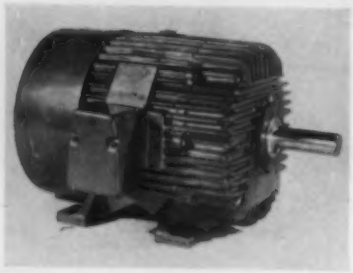
—You can count on Continental.

Continental Screw Co.

Manufacturers of Holtite Fastenings
New Bedford, Massachusetts, U.S.A.

of light to medium viscosities at pressures to 125 psi. The pumps are UL-approved for handling hazardous liquids such as naphtha and benzine, having a special stuffing box and an alternate mechanical seal. Wayne Pump Co., 113 Tecumseh St., Fort Wayne, Ind.

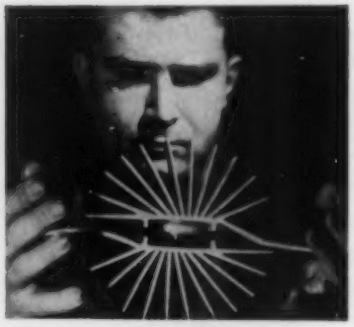
For more information—
Circle 21, inside back cover



Induction Motors in New Frames

This line of integral horsepower induction motors in NEMA frames (up to 30 hp) is available in a ribbed frame and in dripproof design, which is also essentially splashproof. Crocker-Wheeler Div., Elliott Co., Jeannette, Pa.

For more information—
Circle 22, inside back cover



Air-Cooled Germanium Rectifier

An air-cooled germanium rectifier, incorporating automatic voltage stabilization and remote stepless reactor control at no extra cost and designed for plating application, has been announced.

Output voltage is controlled by a reactor, eliminating moving parts, and reducing maintenance cost and down time. Voltage is maintained automatically, regardless of changes in tank load or variations in a-c line voltage.

The rectifier has a cooling system, consisting of silver-plated aluminum fins that surround the germanium cell, conducting heat away from both sides. Formerly, germanium junctions were cooled from only one side. Units, which occupy less than 9 sq ft of floor space, are presently available in ratings from 6 to 24 v and up to 4000 amp. General Electric Co., Lynn, Mass.

For more information—
Circle 23, inside back cover

Oil and Bearing Seal

For sealing of light oils when no head of oil exists, this seal is a special lamination of hycar and felt. It is compressible for tight fit, grease absorbent for low friction, and is said to consist of a hard, tough fibrous structure. The seal is satisfactory when used under acid conditions to 2.5 pH, and will withstand mild alkaline solution at normal temperatures. The unit may be used in any of the common types of seal construction. These include machined, grooved, recessed grooved, stuffing box type, multi-grooved type and inserted in metal stamping. The seal can be supplied cut to any shape. Felters Co., 210 South St., Boston 11, Mass.

For more information—
Circle 24, inside back cover

A-c and d-c Tachometer Generators

Small diameter tachometer generators for applications such as speed measuring and regulation have been designed for incorporation into variable-speed drive systems. The totally-enclosed units are of ball-bearing construction.

The four-pole, a-c tachometer serves a speed range of 400 to 5000 rpm.

The unit has a voltage output of 28 v per 1000 rpm, ±10 per cent, according to the maker. The generator, 6 in. long and weighing less than 4 lb, is available in base or machined and flange mountings. Low shaft inertia (1.4 lb in^2) and 1.5 per cent ripple are provided in the d-c tachometer generator, which is 7.47 in. long and weighs approximately 6.5 lb. Diameters of both d-c and a-c units are the same, 3⅞ in. General Electric Co., Schenectady 5, N. Y.

For more information—
Circle 25, inside back cover

Digital Volt-Ohmmeter

This three-digit instrument, designed especially for industrial uses, is available in both portable and rack mount models. In-line luminous numerical readout can be read from 30 ft or more, from straight-on or at angles. Accuracy provided on d-c volts is ±0.1 percent, a-c volts ±2 per cent of full scale from 30 cps to 3 megacycles for voltages greater than 1 v: ohms, ±0.1 per cent of value, ±1 digit. This instrument offers these manually-selected ranges: a-c, 0.01 to 999; d-c, 0.001 to 999; and ohms, 1

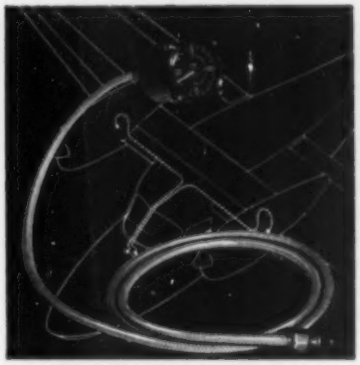
CONTINUED ON PAGE 230

FLEXIBLE SHAFT IDEAS for ENGINEERS

Gain extra design freedom... create cost-saving opportunities with S.S.White flexible shafts

S.S.White "Metal Muscles"® are readily adaptable to a wide range of space, operating and service requirements

BY USING S.S.WHITE FLEXIBLE SHAFTS to transmit power or control between two points, many of the restrictions placed on a design by rigid connections can be quickly removed.



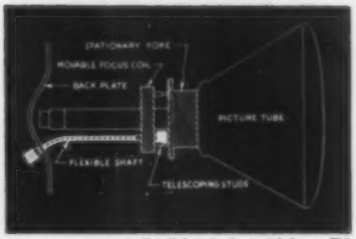
A flexible shaft tachometer drive application.

Save time and costs

Power sources and driven members or controlled parts and their controls can be positioned to better advantage. Costly methods of connection and adapting can be eliminated and general overall design can be improved. And, because an S.S.White flexible shaft does away with alignment problems and reduces the number of parts required for a control or power drive, costly and time-consuming assembly operations can be avoided.

Early consideration best

By far the best time to consider using S.S.White flexible shafts is when your product is still in the design stage. Then you can use them to maximum advantage and will also have a wider selection of shaft sizes, styles and characteristics to choose from than if your design is "locked up."

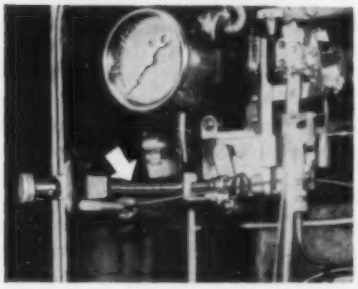


A remote control flexible shaft used in a TV-focusing device.

Satisfaction assured

Once selected, you can always count on S.S.White flexible shafts to measure up to the requirements of your application. S.S.White's many design and manufacturing developments have made S.S.White flexible shafts first in the field for quality, performance and dependability. Experience has shown that when it comes to flexible shafts you'll always be right – if you specify "S.S.WHITE".

"Coupling"... a money-saving flexible shaft idea



SHORT LENGTHS of S.S.White Flexible Shafting, used to "couple" two adjacent parts within the confines of a piece of equipment are a simple economical answer to many power drive and control problems.

Only a single length of shafting is needed regardless of *the relative position of the parts.* The shaft functions satisfactorily without vibration even under conditions of misalignment, thereby insuring trouble-free service and simplifying assembly operations. A typical flexible shaft coupling application is shown above.

Engineering cooperation on flexible shaft application problems

PROPER SELECTION AND APPLICATION *are essential if you are to get the most out of a flexible shaft. The services of our engineers – long experienced in solving all types of flexible shaft problems – are available for this purpose. May we cooperate with you on a specific current problem? There's no obligation. It will save you time and trouble.*

A "must" for every design engineer

Bulletin 5601 contains the latest information on flexible shafts, tells how to select and apply them. Send for your copy today.

FS-5

S.S.White

FIRST NAME IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION, DEPT. D, 10 EAST 40th ST., NEW YORK 16, N.Y.

Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

ohm to 9.99 megohm. The portable instrument is 11 x 8¼ x 15⅛ in. deep. Non-Linear Systems, Inc., Del Mar Airport, Del Mar, Calif.

For more information—
Circle 26, inside back cover

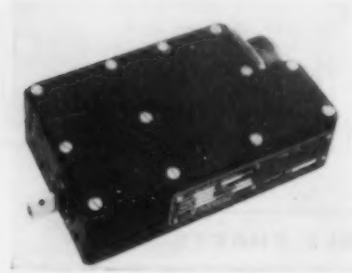
Magnetic Motor Controller

This relay is available in single-pole (normally open or normally closed), and single-pole, double-throw contacts. It is rated for 1 hp, 115 v a-c or 1½ hp, 230 v a-c at 60 cps. All UL requirements are met. Dimensions are 1⅜ x 2⅝ x 1⅜ in. Weight, 0.5 lb. max. U. S. Relay Co., 1740-44 Albion St., Los Angeles, Calif.

For more information—
Circle 27, inside back cover

Servo-Controlled Actuator

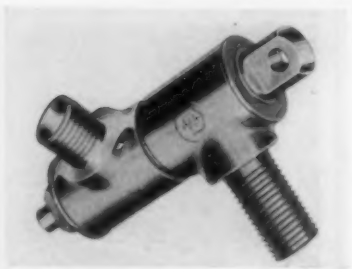
This 400 cps servo controlled actuator was designed for airborne applications and was intended to be operated from magnetic, transistor or vacuum tube amplifiers. It can be supplied in two output torque ratings: 100 in-lb at stall and 50 in-lb at 1.8 rpm, or 50 in-lb stall and 25 in-lb at 3.6 rpm.



This actuator is available either with or without a-c tachometer feedback for stabilization purposes. Position feedback may be provided by either internal potentiometer or synchro signals. Internal fixed stops and limit switches can be incorporated if required.

Maximum overall dimensions excluding shaft extension is 6 x 3⅞ x 1¾ in. deep. White Rodgers Co., 4407 Cook St., St. Louis 13, Mo.

For more information—
Circle 28, inside back cover



Swivel Joint for Fluid Systems

A pressure-balanced, low torque swivel joint of the plane-type design does not depend upon piping to drive or rotate. Shaft may be actuated with a mechanical drive rod, eliminating tube fatigue at piping connections. Need for bearings or other anti-friction parts is said to be eliminated. It is suitable for hydraulic, pneumatic, gaseous and vacuum-carrying installations in aircraft piping systems. Weatherhead Co., 300 E. 131 St., Cleveland, Ohio.

For more information—
Circle 29, inside back cover

Self-Locking Nuts

These nuts are made for several bolt and screw sizes. They can be reused repeatedly without impairing their locking ability and are installed with standard tools, such as pliers and hex wrenches. The nuts are now available for screw sizes ranging from No. 4 through ⅝ in. Con-Torq, Inc., North & Judd Mfg. Co., New Britain, Conn.

For more information—
Circle 30, inside back cover

High Speed Sampling Switch

Up to 40 shorting channels or 20 non-shorting channels are provided by these switches, adaptable to a variety of motor drives. Available with bronze or ball bearings, approximate dimensions are 1⅝ in. square by 1⅛ in. long, plus shaft ¼ or ⅛ in. dia by ½ in. long. Current models include single or multiple pole, stacked, concentric, opposed, raised contact, segmented or printed circuit designs. General Devices, Inc., Princeton, N. J.

For more information—
Circle 31, inside back cover

Solenoid Pilot Valve

A line of small solenoid pilot valves capable of handling air, vacuum, oil, water and inert gases is available in both two and three-way types. The valves are designed for control of remote pilot-operated valves or direct control of small cylinders and similar devices.

Capacities range up to 23.8 cfm air and 3.8 gpm hydraulic. Valves are said to be capable of controlling over 600 cycles per minute. Both plunger and spring, the only moving parts, are of stainless steel. Seats and O-ring seals are of Hycar. Cylinder ports are tapped ¼ in. NPT and electrical con-

CONTINUED ON PAGE 232

MAKE IT WEIGH LESS

N-A-X

HIGH-TENSILE STEEL

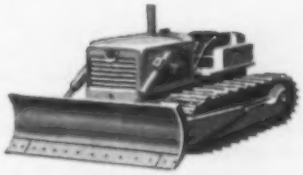
MAKE IT LAST LONGER

You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel – it can be cold formed as readily into the most difficult shaped stamping.

When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel – long recognized specialists in flat-rolled steel products.



N-A-X Alloy Division

GREAT LAKES STEEL CORPORATION

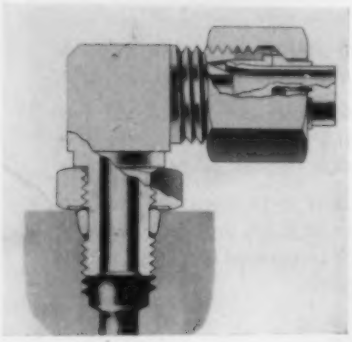
Detroit 29, Mich. • A Unit of

NATIONAL STEEL CORPORATION

duit connections are tapped ½ in. NPT. Valves can be supplied for direct pipe connections, with subbase, or drilled for mounting on customer's manifold.

Solenoid coils are supplied for 3 to 300 v d-c, 6 to 550 v a-c and 25 to 60 cps. According to the manufacturer, maximum solenoid coil current consumption is 10 w. Valvair Corp., 454 Morgan Ave., Akron 11, Ohio.

For more information—
Circle 32, inside back cover



O-Ring Locknut Fitting

A straight-thread, O-ring locknut fitting, available in all styles and in sizes from ⅛ to 2 in. is claimed to be leakproof, provide safer high pressure connections and be easy to position. In addition, the new hydraulic fitting is interchangeable and meets all SAE and JIC standards. Flodar Corp., 16911 St. Clair Ave., Cleveland 10, Ohio.

For more information—
Circle 33, inside back cover

Lubricant for Nylon

This is a dry base lubricant that utilizes the principle of regelation, becoming wet and slippery as pressure is applied, then resolidifying instantly as pressure is relieved. Parts to be lubricated are dipped or sprayed with a very light film. Average reapplication is every 6 mo, the maker reports. Synco Co., United Artists Building, Detroit 16, Mich.

For more information—
Circle 34, inside back cover

Epoxy Resin Adhesives Cure At Room Temperature

Three epoxy resin adhesives, that cure at room temperature under contact pressure to a strong solid state without forming volatile by-products, are now available. All three can be used for bonding aluminum, brass, copper, steel and other metals to each other, to glass and to many plastics. They are each cured with different activators to form epoxy resin adhesives that have 100 per cent solids content. Minnesota Mining & Mfg. Co., 423 Piquette Ave., Detroit 2, Mich.

For more information—
Circle 35, inside back cover

Miniature Motor and Gear Train

With a governor-controlled planetary gear train with integral filter, a miniature motor has an overall length of 2.912 in. from mounting flange. Applications include timing units for telemetering, commutator switching and kindred functions. Load is 3 in-oz, weight 5½ oz output speed may be specified for 15, 20, 150, 300, 600 or 1800 rpm. El Ray Motor Co., Inc., 11747 Vose St., N. Hollywood, Calif.

For more information—
Circle 36, inside back cover

Adjustable-Speed Drives

Both ¼ and ½ hp models are available with either geared or ungeared motors. Motor armature delivers a constant torque at a speed that is in-

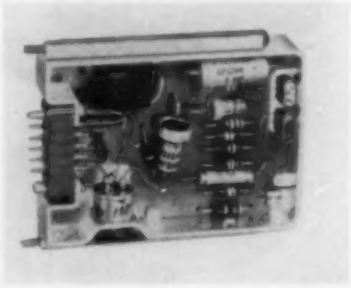
finitely adjustable from near zero to 2400 rpm. A compact control head utilizes only low voltage circuits that can be easily installed at a point remote from either the motor or rectifier cabinet. The rectifier cabinet is finished in baked green enamel and can be either wall or bench mounted. Servo-Tek Products Co., Inc., 1086 Goffle Road, Hawthorne, N. J.

For more information—
Circle 37, inside back cover

Subminiature Servo Amplifiers

Transistor models include 1 and 3 w units using silicon transistors and 6 and 9 w units using germanium transistors. These units are designed for 400 cps servo motors in airborne service, and vary in size from 6 to 12 cu in. and weigh from 4 to 5 oz. Other transistor amplifiers include resolver, summing, automatic gain control, preamplifier and demodulator units.

Vacuum-tube models include a 5 w amplifier and a precision summing amplifier that handles up to seven in-

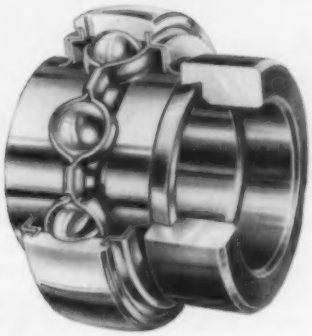


CONTINUED ON PAGE 234

NEW! Fafnir Wide Inner Ring Ball Bearings with PLYA-SEALS . . . *contact type*

A most important feature *. . . on slow-speed applications where service conditions are excessively dirty and moist*

RCJ Flange Cartridges
(Standard Series)



RAK, RAS Pillow Blocks
(Standard Series)

Plya-Seal Construction — for wide inner ring ball bearings. A synthetic rubber, contact-type seal located between two "dished" steel plates for extra rugged support.

With the addition of this version of PLYA-SEALS to the Fafnir line of wide inner ring ball bearings, you can be more selective in the type of sealed bearing you specify and install. Where service at slow to moderate speeds demands most effective protection against contaminants, especially air-borne dust, dirt and grit, the Plya-Seal type offers the advantages of contact seals, tested and proven by years of service.

Plya-Seal Wide Inner Ring Bearings are optional on the standard series Pillow Blocks and Flange Cartridges. They are dimensionally interchangeable with the Fafnir Mechani-Seal. Flared lip and clearance between inner supporting seal member and inner ring O.D. keeps seal from pushing in. Plya-Seals do not absorb contaminants, thus their surface won't glaze and lose its efficiency. *Fafnir Wide Inner Ring Bearings equipped with Plya-Seals are relubricatable!*

Here's an opportunity to improve operations, reduce servicing, eliminate loss of lubricant, provide the most effective protection from contaminants. For new Bulletin on Plya-Seal Wide Inner Ring Ball Bearings, ask your Authorized Fafnir Distributor or write The Fafnir Bearing Co., New Britain, Conn.

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

puts at an accuracy of ±0.05 per cent. This unit also provides 90 deg phase shift if desired. This amplifier weighs 4 oz and occupies 4 cu in. W. L. Maxson Corp., 47-37 Austell Pl., Long Island City 1, N. Y.

For more information—
Circle 38, inside back cover

Four-Cylinder, V-Type Engine

The engine delivers 70 hp at 3000 rpm. A four-throw, three-main-bearing dynamically counterbalanced crankshaft and twin three-bearing camshafts are part of the engine design. All engine accessories are flange-mounted and gear driven from the timing gear train housing.

The CV4-180 weighs approximately 463 lb, less electric starter, generator and flywheel housing, which are being offered as optional equipment. The engine power end will be offered with SAE No. 3, 4, and 5 bell housings as well as with special pump adaptors and shaft extensions. Lycoming Div., Avco Mfg. Corp., 550 S. Main St., Stratford, Conn.

For more information—
Circle 39, inside back cover

Solid Electrolyte Battery With Unlimited Shelf Life

Designed for low-current applications, the battery is made primarily of silver, silver iodide and vanadium pentoxide. Tests are reported to have indicated that the battery should give up to several decades' continuous service in suitable applications, such as maintaining a change on capacitors in electronic circuits.

The battery is 1 in. long and weighs ¼ oz. It is rated at 95 v. A continuous current drain of 10 micro-microamp can be maintained, with flash currents in the microamp range. In service, the battery can withstand temperatures ranging from −70F to 170 F with no appreciable change in voltage. National Carbon Co., 30 E. 42 St., New York 17, N. Y.

For more information—
Circle 40, inside back cover

Teflon Tubing and Lined Pipe

Teflon pipe is being made up to 4 in. dia; lined pipe in 2 in. sizes. It is also available in rods and special machine parts. The pipe, tubing and rods, and lined steel pipe can be cut to desired lengths in the field and readily flanged. Haveg Industries, Inc., 900 Greenbank Road, Wilmington 8, Del.

For more information—
Circle 41, inside back cover

Hermetically Sealed Relay

The possibility of contact contamination is said to be eliminated in a relay which has hermetically and individually sealed contacts. The unit is available with coils designed for use at 6, 12, 24 or 48 v d-c. Contacts are normally open or normally closed, and are rated at 0.5 amp inductive or resistive at 28 v d-c. Revere Corp. of America, Wallingford, Conn.

For more information—
Circle 42, inside back cover

Multiple Branch Conductor

Developed for missile wiring, this cable contains 141 conductors. It permits continuous circuitry, as there is no junction in the "breakout." Circuits can be completed between any two or all three branches of the "breakout" without originating in the prime cable.

The cable retains flexibility from −65F to 175F. Pacific Automation Products, Inc., 1000 Air Way, Glendale 1, Calif.

For more information—
Circle 43, inside back cover

Tachometer Takeoff

These takeoff heads measure speeds between 100 and 5000 rpm. They are now available with AN screw mounts for aircraft tachometer takeoffs, and also with SAE screw mounts for gasoline, diesel, marine, railway or stationary engines and compressors.

A double-pole, double-throw switch with a capacitor senses speed when the takeoff shaft rotates either direction. A current (linear with respect to speed) is transmitted to a centrally

CONTINUED ON PAGE 236

BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

Bridgeport Brass Co.

Reporting new developments in copper-base alloys and metalworking methods.

These copper wall tiles made from Bridgeport copper are ideal where rich, warm decoration is desired. (Photo courtesy House of Time, Inc.)

Bridgeport Copper Gives Gleaming Beauty to Vikon Tile

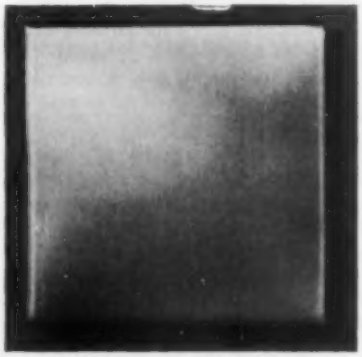
Vikon Tile Co., Washington, N. J., manufactures a complete line of metal and plastic tile. For their copper tile, widely used in kitchens and for decorative effects, it was important that the material chosen fit very exacting requirements—and Bridgeport Copper met those specifications.

The copper had to be easy to cold-work and have the right temper to give the desired rigidity after forming. It had to have a consistently unblemished surface to assure a uniform finish. Ease of lacquering was also important.

For these tiles, Bridgeport recommended and supplied Alloy #102, 28 gage (.0126 in. thick) roll copper.

The roll copper is first put through a passifator bath to retard tarnishing. After drying, the passifated copper is sent to presses for stamping. The stamped tiles then go to the spray department where they are coated front and back with a clear synthetic lacquer. This finish is baked on the surface, and serves as a further protection against tarnishing.

This is another successful example of a Bridgeport metal that is *matched to the job*. Vikon, like other manufacturers, has found Bridgeport a dependable source of quality material.



Finished tiles have a beautiful satin-like sheen. The burnished surface allows tiles to be alternately placed to obtain checkerboard patterns.

Railhead Bond Made From Bridgeport Phono-Electric Rod Gives Dependable Service

Hanlon & Wilson Co. of Wilkinsburg, Pa., manufactures their quality rail bond from Bridgeport Phono-Electric Cadmium Copper, Alloy #985.

For the terminals, Hanlon & Wilson needed a metal that had a coefficient of expansion approximating railroad steel . . . one that had excellent cold-flow properties as well as high conductivity. High strength and maximum resistance to corrosion were also desirable qualities.

Bridgeport Technical Service studied the requirements for the rail bond, then suggested Alloy #985, Phono-Electric Cadmium Copper rod, in ½" diameter. Terminals were drilled through, pressed in three operations and rotary swaged to the cable. The cable strand is made from Alloy #985 wire.

Hanlon & Wilson Co. rail bonds are shown before plating (at left) and after plating (at right).

Both in manufacturing processes and in actual use, Bridgeport Alloy #985 proved to be entirely satisfactory. Why? Because the metal is *matched to the job it is expected to do*. This metallurgical service is available to you without obligation. Just phone or write your nearest Bridgeport Sales Office for expert advice . . . and for high-quality brass, copper and aluminum. (013)

Bridgeport Brass Co.

BRIDGEPORT BRASS COMPANY ♦ BRIDGEPORT, CONNECTICUT

Mills at Bridgeport, Conn., Indianapolis, Ind., and Adrian, Mich. Sales Offices in Principal Cities—Conveniently Located Warehouses

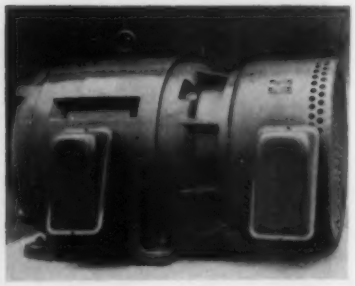
located, separate indicator unit up to 100 ft away. Either of two stainless steel keyed shafts are standard. Also available are two alternate shafts: ⅜ in. round and ¼ in. square. Heavy duty ball bearings are ⅝ in. OD. Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.

For more information—
Circle 44, inside back cover

Catalytic Epon Finish

A liquid plastic finish that protects metal and wood surfaces incorporates a modified catalytic epon with other plastic resins, and is said to handle easily in brushing, spraying and dipping operations. It air dries in 6 hr, bakes glossy hard in 8 min at 350 F. Mixing consists of combining two liquids in equal parts. The finish is available in any color as well as clear, and in hammertone, metalescent and leatherlike finishes. Surface Coating Engineers, Inc., 2417 N. Burdick St., Kalamazoo, Mich.

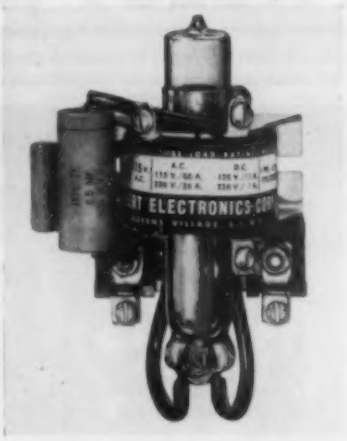
For more information—
Circle 45, inside back cover



Brushless Frequency Converter

Unit consists of 25 kva alternator, direct mounted on a continuous duty induction motor. Output is three-phase, four-wire, 120/208 v. Exciter is unnecessary. Due to absence of rf disturbance, suppression is not required. Overall dimensions of unit are 36 x 20 x 20 in. Weight 925 lb. Georator Corp., Manassas, Va.

For more information—
Circle 46, inside back cover



Relay for Up to 60 amp

This unit is said to allow extremely low surge current through the actuating coil, preventing damage to fine instrument control contacts. It requires 0.0035 amp from an external contact (thermometer, contact-meter, probes) to operate. Power amplification is 17,300. The load rating is 60 amp at 115 v a-c; 35 amp at 230 v a-c; 12 amp at 440 v a-c on motor, general purpose or tungsten lamp loads. Ebert Electronics Corp., 212-320 Jamaica Ave., Queens Village 28, N. Y.

For more information—
Circle 47, inside back cover

Automatically Counts and Prints Count

A device that automatically counts and then, at some specified time, prints the count, can be caused to print at regular intervals so that it is possible when reviewing the chart to determine the number of counts in any particular time period. The unit is ideally suited for a print-out device for integrators and mounting can be provided for all popular makes of recorders. It can also be supplied as an independent unit for printing on a card or adding machine tape. The Model RI-4 can be supplied with as many as 8 digits so that a maximum count of 100 million is possible.

Printing does not affect the counting so that the counting can continue after printing the particular number since the counting circuit and printing circuits are independent of each other. Both the counting solenoid and the printing solenoid can be supplied for any d-c voltage from 24 to 220 v, and rectifiers can be supplied for use on a-c if desired. Royson Engineering, Hatboro, Pa.

For more information—
Circle 48, inside back cover

Multiple Circuit Plug and Receptacle

For use in major appliances, electronic equipment, machinery or any application requiring multiple circuit hook-ups these connectors have crimped terminals for snap-in assembly, eliminating soldering. Terminals are available individually or in reels for automatic machine assembly to wires.

Rated up to 15 amp per terminal the units are UL approved. Molex Products Co., 9515 Southview Ave., Brookfield, Ill.

For more information—
Circle 49, inside back cover

Nylon Bearings

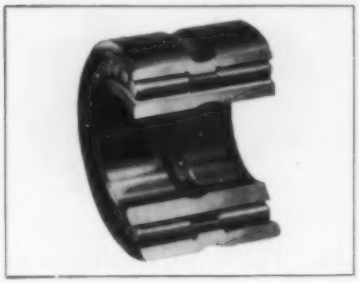
A line of straight and flanged nylon bearings available in 39 stock sizes ranging from ¼ to 1 in. ID are said to be suitable for all shaft applications where reciprocating, oscillating or rotating motion is involved. The bearings are recommended for use with

CONTINUED ON PAGE 238

BEARING TIPS by McGill

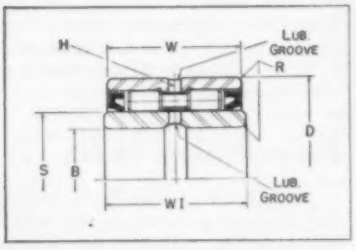
CAGELESS BEARING CORRECTS SKEWING

Guiderol Bearings carry greater loads in smaller spaces because they have no space wasting cages. A full complement of center grooved rollers extends the width of the race for maximum load support and a center guide rail avoids roller skewing that can bind a bearing under some loads. MT and CT series interchange dimensionally with ordinary needle bearings and cylindrical roller bearings.



First Sealed Full Type Roller Bearing Series

The SG series Guiderol bearing provides low-cost and flexible sealing where ordinary needle-type bearings with auxiliary seals have been too cumbersome and expensive. Interchangeable with the standard Guiderol bearing, the new SG series provides five sealing combinations.



140 Pages of Bearing Facts

Write for your copy of Catalog No. 52, a revised 140-page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.

GUIDEROL® BEARING CARRIES GREATER LOAD IN SMALL SPACE FOR McCULLOCH CHAIN SAWS

Bearings installed in 1944 still in use.

Load-carrying capacity in minimum space is given as the reason for using McGill Guiderol bearings on the heavy-duty loader made by the Farmhand Company. Four bearings support the shafts of the gear pump that furnishes hydraulic power to the loader. Guiderol bearings have been used by Farmhand since 1944 and virtually all of the loaders with the original bearings are still in use.

Assembly ease cited as an extra benefit

Rugged use in the field dictates rugged construction at the factory for McCulloch Motors Corporation gasoline engine chain saw units. The one-man and two-man chain saws must be light and compact but sturdy enough to operate at full capacity all day long.

Since switching to a McGill Guiderol Bearing as support for the crankshaft, McCulloch, like many machine builders, has proved that the Guiderol bearing provides the desired greater load capacity in small space and outlasts former units with minimum maintenance—important under rugged chain saw field conditions.

A bonus benefit is the ease of installation of the Guiderol bearing—with open ends and no end shoulders. Assembly is a simpler operation.

Insure performance with McGILL®

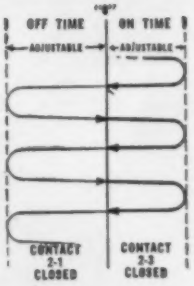
MULTIROL® GUIDEROL® CAMROL
Full Type Roller Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

EAGLE FLEXOPULSE
repeat cycle timer
WITH S.P.D.T. SWITCH

No gear change or resetting of cams required

This Flexopulse Repeat Cycle Timer is ideal for controlling processing machines requiring adjustable timed cycles. The "on" or "off" intervals are easily adjusted. Either can be adjusted without disturbing the setting of the other. Instead of resetting cams or changing gears, simply loosen two knurled nuts. Then set "on" and "off" periods by moving adjustable pointer. Tighten screws, and the job's done.



HAS CYCLE PROGRESS INDICATION:

A movable flag indicator passing over the time scale between adjustable arms, indicates portion of cycles elapsed in either of the s.p.d.t. positions. Switching operation takes place at zero. Flexopulse is ideal for periodically operating valves to reverse the flow of liquids, for operating signals or for injecting chemicals. 120-second up to 20-hour dials are available. Synchronous motor powered. Send coupon today for free Bulletin 320.

FREE BULLETIN, MAIL COUPON

EAGLE TIMERS SAVE TIME . . . SAVE MONEY
EAGLE
SIGNAL CORPORATION
Industrial Timers Division
MOLINE, ILLINOIS

EAGLE SIGNAL CORPORATION
Industrial Timers Division, PE-1056
MOLINE, ILLINOIS

Please send free Bulletin 320 with full data on Flexopulse Repeat Cycle Timer.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

steel shafts and may also be used with brass or bronze. The bearings are reported to support loads in excess of 206 psi at rubbing velocities of 525 fpm and more. Tolerances are held to 0.005 in. over shaft size, ± 0.001 in. while OD is held to 0.004 in. over the fractional size, ± 0.001 in. Climax Metal Products Co., 863 E. 140 St., Cleveland 10, Ohio.

For more information—
Circle 50, inside back cover

D-c Tachometer Generators

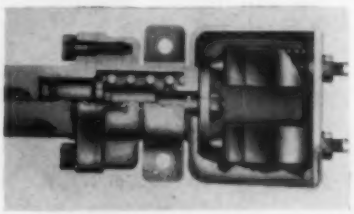
This line of generators is available in two basic model series, depending on the degree of compensation required. Units can be furnished with outputs held to less than 0.1 per cent or to less than 0.25 per cent voltage variation due to temperature changes over a range of −40C to 100C.

Available outputs are from 1 to 175 v per 1000 rpm, with operating speeds up to 10,000 rpm or higher as required. Electric Indicator Co., 100 Camp Ave., Springdale, Conn.

For more information—
Circle 51, inside back cover

Piston Pressure Switch

This switch is capable of sensing two different pressures in one system and actuating independent electrical circuits at any two desired points. They may be used to maintain a pressure where it is imperative that the system pressure does not exceed or fall



(Continued on page 243)

How optical gaging helps get Giannini air-borne instrument production off the ground faster.

In the fight for flight that's higher, farther, faster—plane and missile makers want everything smaller, lighter, tighter. Tighter means tolerances today of 0.0002″ to 0.0003″ compared to 0.003″ to 0.004″ a few years ago. That's why more and more manufacturers like aircraft and missile instrument and control maker G. M. Giannini & Co., Inc., Pasadena, Calif., are using Kodak Contour Projectors.

A pulley in one Giannini instrument is less than pencil eraser size, has groove dimension tolerance falling between 0.010″ and 0.011″, four separate angles to check out within 0.30°, a shaft diameter of plus or minus 0.0001″ or 0.0002″. Perpendicularity must be within 0.0003″. Like many aircraft parts, it's made of aluminum alloy.

Before Giannini put a Kodak Contour Projector to work on receiving inspection, getting prototypes of instruments filled with parts like this—and even tighter—used to be a mammoth problem. An undetected off-tolerance part in the master could hold up production or even throw production models out of kilter.

At Giannini, inspectors check incoming parts quickly and accurately with optical gaging, make sure they're right for the prototype. They optically check angles, shoulders, radii, positions, and all critical surfaces on a single projector. Now there's less chance than ever that production parts will be off tolerance once the master has been approved.

If inspecting small parts to tiny tolerances is a large problem with you, you should investigate optical gaging with a Kodak Contour Projector. A Kodak Contour Projector can work production and quality control miracles where control of measurements makes a better product.

Write for your copy of "Projection Gaging with Kodak Contour Projectors." Even better, ask for the name of your nearest representative, so he can personally explain projection gaging's scope and capabilities.

Inspectors quickly learn optical gaging, because it's simply a matter of looking and comparing. Perhaps you can greatly improve Toolroom, Receiving, Production, and Final inspection with a single unit. There are six models to choose from.

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

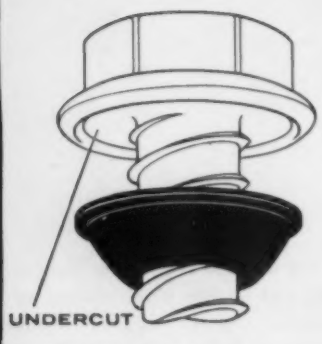
the KODAK CONTOUR PROJECTOR

Kodak
TRADE MARK

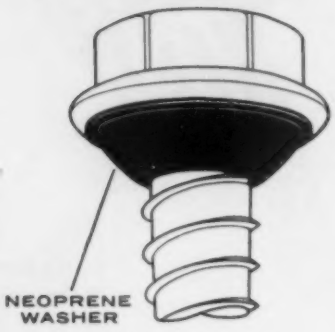
For better products

LEAKPROOF...CUSHIONED TUFF-TITE FASTENERS

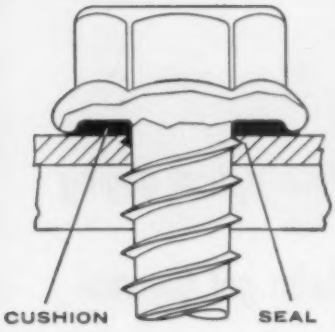
trademark



Undercut of Tuff-Tite fastener head . . .



. . . confines and controls flow of conical neoprene washer



. . . so washer seals the hole and cushions the fastener head!

Now you can • prevent leaks at fastener holes
• protect fine finishes from fastener damage
• stop vibration noises and squeaks

It's the combination of undercut head design and tough, conically shaped neoprene washer that makes Tuff-Tite fasteners work. The undercut helps confine and control spread of the neoprene washer as it is compressed. The washer's conical shape causes it to flow into top threads and seal the fastener hole.

Tuff-Tite fasteners won't mar fine finishes and they stop vibration noises and squeaks because the neoprene washer spreads itself completely between fastener head and surface. The washer actually cushions the fastener and prevents metal-to-metal contact.

Leakproof, non-marring, shock and squeak absorbing! If you need these fastening advantages, you need National Tuff-Tite fasteners. Write for the Tuff-Tite fastener folder describing this line in detail.

THE NATIONAL SCREW & MFG. COMPANY
CLEVELAND 4, OHIO
Pacific Coast: **National Screw & Mfg. Co. of Cal.**
3423 South Garfield Ave., Los Angeles 22, Cal.

Tuff-Tite fastener facts

Standard National Tuff-Tite fasteners are available in hexagonal, pan, round and truss head styles for screw diameters No. 6 to $\frac{3}{8}$" inclusive . . . maximum over-all length $1\frac{1}{2}$". Standard fastener types are wood screws, self-tapping screws, thread cutting screws, machine screws and stove bolts. Tuff-Tite fasteners are pre-assembled with neoprene washers.

Washers are molded of neoprene which has a durometer hardness of 85 to 95.

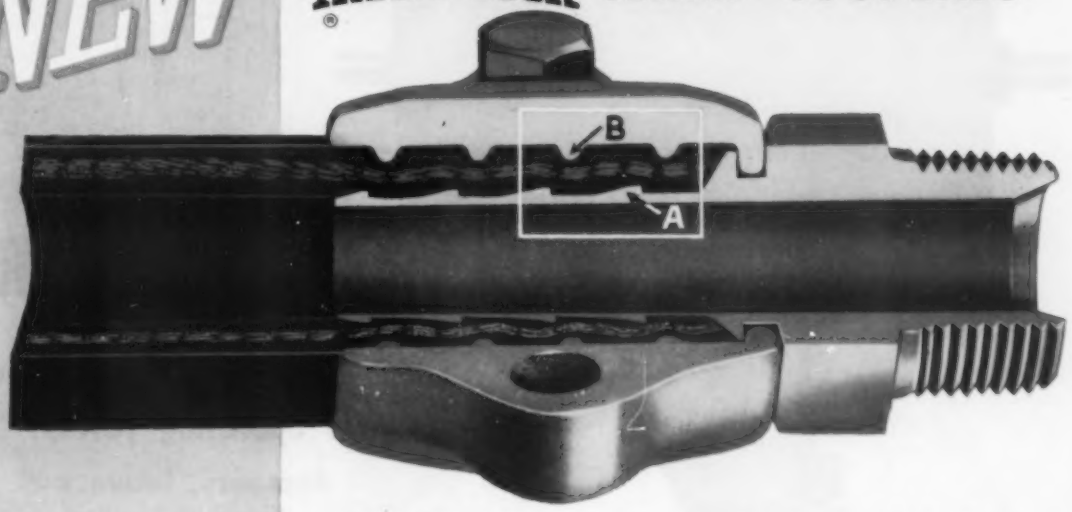
Write for information on *special* Tuff-Tite fasteners.

National PRODUCTS

Fasteners **Hodell Chains** **Chester Hoists**

NEW Eastman

INTER-LOCK® CLAMP COUPLING



EASTMAN MFG. CO. announces its New **Inter-Lock** Clamp Coupling—offering *exclusive grip advantages* available in no other coupling of its type.

EXCLUSIVE EASTMAN INTER-LOCK FEATURES

Eastman's New **Inter-Lock** Clamp Coupling provides positive positioning through accurate machining of clamp and insert—as the outside rib of the clamp is locked between the collar and hex of the insert, before tightening.

The accurate location of the clamp over the insert assures alternate mating of the barbs of the insert (A) with the circular ribs of the clamp (B).

Hose is uniformly compressed into each alternating recess—increasing the holding power of the Clamp Coupling—thereby creating **Eastman's Exclusive Inter-Lock Grip.**

Longer service is assured because hose construction is not weakened by pinching, as it may be if ribs and barbs were permitted to fall directly opposite each other.

EASTMAN'S Exclusive **Inter-Lock** feature is another example of advanced design and engineering which gives you greater value, plus the *all-important competitive advantage* of superior product performance and customer satisfaction in the field.

Look to EASTMAN . . . *first in the field* of Hydraulic Hose Assemblies . . . for continued leadership in design and engineering—plus the highest quality material and workmanship.

STANDARD INSERTS FOR EASTMAN INTER-LOCK CLAMP COUPLING

For low, medium and high pressure hose up to 5000 psi. working pressure. Available for hose sizes ranging from ¼" to 2" I.D.—according to pressure requirements. Also available for angle and straight tube applications.

SWIVEL FEMALE

MALE PIPE

MALE FLARE

INSERT FEATURE

Beveled shoulders of barbs permit easy insertion into hose.

WRITE for Standard Sizes or send your blueprints and specifications.

SAFEGUARDING INDUSTRY'S Lifelines of Mobile Power

Eastman

first in the field

MANUFACTURING COMPANY

Dept. PE-10, Manitowoc, Wis.

NEW

ACTIONATOR

heavy duty electric motor for operating valves, dampers, louvers

The new Honeywell ACTIONATOR* is a compact, lightweight, rugged and flexible industrial motor for operating valves, dampers, louvers, and other final control elements. Models for boss mounting or with integral valve yoke for installation on slip stem valves. Internal strain release protects valve seats and gear train. Squared shaft ends facilitate actuating lever attachment.

The ACTIONATOR is available in reversing or unidirectional models for on-off or two-position control, and in reversing models for floating or proportional control. Shaft rotation can cover up to 180 degrees in 7½, 30, 60, or 120 second timings; torque ratings from 50 to 200 inch-pounds.

To match the ACTIONATOR with the proportional electric controller, slidewire resistances of 100, 135, or 1000 ohms are offered. A second slidewire can be used for retransmission . . . to operate another motor, or for remote indication. Spst and spdt auxiliary switches can also be installed within the end bells. The enclosed terminal compartment is designed to meet J.I.C. standards.

Specially designed MICRO SWITCH switches allow the ACTIONATOR to be used where ambient temperatures range from −20 to +150 F.

For complete information and specifications on the new ACTIONATOR, call the nearest Honeywell office, or write (send coupon) to:

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Phila. 44, Pa.

Industrial Division
MINNEAPOLIS-HONEYWELL REGULATOR CO.
Wayne and Windrim Avenues, Philadelphia 44, Pa.

☐ Please send me additional information on the ACTIONATOR.

☐ I'd like a Honeywell sales engineer to discuss applications of the ACTIONATOR in my plant.

Name_____

Title_____

Company_____

Address_____

*Tradename Minneapolis-Honeywell Regulator Co.

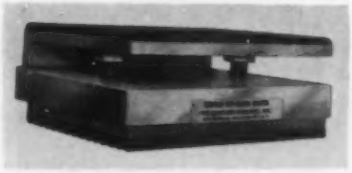
Honeywell

First in Controls

below predetermined values. They accurately sense any system pressure over an adjustable range of 15 to 3000 psi for proof pressures from 3000 to 7000 psi, depending on the switch setting. The switch incorporates two UL-approved, single-pole, double-throw snap action switching elements rated for a-c and d-c circuits. Each switching element is electrically independent of the other.

Two calibrated dials permit visual setting of either switch, without gages, before or after installation on a pressure line. Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

For more information—
Circle 52, inside back cover



Self-Leveling Vibration Mount

Internal leveling adjustment permits installation anywhere under the machine, regardless of position or availability of bolt holes in base, or of base thickness. No adjusting bolts protrude from top of the mounting. No bolting of machine to mounting is normally required, because of the nonskid felt pad on the top plate; however, the mounting can be cemented, or bolted through the tapped hole provided. The mount can also be cemented to the floor.

Available in nine sizes, for loads ranging from 65 to 12,000 lb per damper. Korfund Co., Inc., 48-19C 32 Place, Long Island City 1, N. Y.

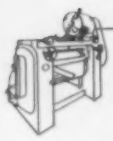
For more information—
Circle 53, inside back cover

Subminiature Snap-Acting Switches

Actuators are integral with the switch body. No adjustment is necessary. Ganging of four switches per inch in miniaturized apparatus is possible, due to measurements of $\frac{1}{4}$ x $\frac{11}{32}$ x $\frac{5}{16}$ in. high. Four types of actu-

(Continued on page 246)

a better kind of power
for the chemical industry

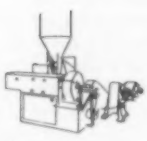


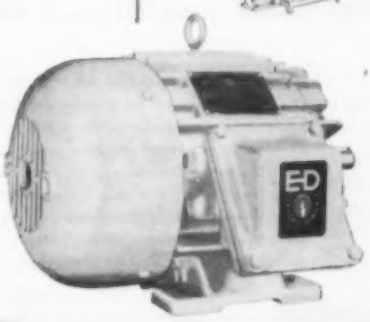
The mark of an Extra Dependable machine

E-D ELECTRO DYNAMIC

A complete selection of *standard* and *special* motors premium-built for chemical applications is now available from Electro Dynamic—America's leading manufacturer of custom-built motors since 1880.

The red E.D. "power spot" is your assurance of *extra dependable* Electro Dynamic power —75 years in the making—yours today *at no extra cost!*





ELECTRO Extra DYNAMIC dependable motors

1 to 250 hp. AC and DC. Standard or special purpose. N.E.M.A. standards.

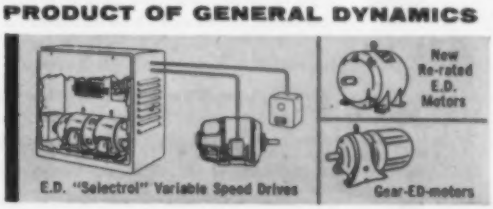
G-D

PRODUCT OF GENERAL DYNAMICS

NEW...

Write for Brochure 100 and literature on new E.D. motors and drives.

Electro Dynamic division of General Dynamics Corporation Bayonne, New Jersey



E.D. "Selectrol" Variable Speed Drives

New Re-rated E.D. Motors

Gear-ED-motors

A good combination...for an argument

Laminated plastics...a combination of properties that *speaks for itself!*

Many industrial applications require materials that can deliver more than one property and can perform more than one function. Such a material is Synthane laminated plastic. This widely used basic material satisfies such diverse property requirements as good tensile, compressive and flexural strengths, low moisture absorption, low dielectric constant and low power factor, light weight and easy machinability. Various grades of Synthane are available to the designer in order to provide him with **just the right combination of properties** according to the mechanical, electrical and chemical requirements of his application.

DIELECTRIC STRENGTH

LIGHT WEIGHT

WEAR RESISTANCE

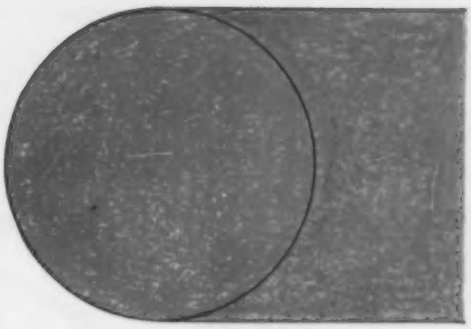
EASILY MACHINED

This insulation plate made of Synthane has to take the toughest kinds of outdoor punishment. Used in heavy-duty generators for bulldozers and tractors, it must battle all kinds of weather, road dust, oils, greases, and vibrations. In addition to meeting these tough service conditions, Synthane also possesses the necessary light weight, mechanical and dielectric strengths, good machining properties, and the ability to be post-formed to the desired shape.

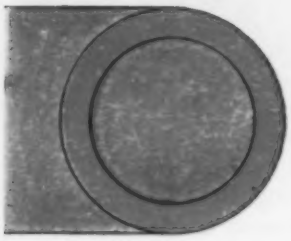
A wide choice of combined properties! Synthane offers over 30 individual grades in sheets, rods, tubes, moldings, and completely fabricated parts. Send for free illustrated catalog today.

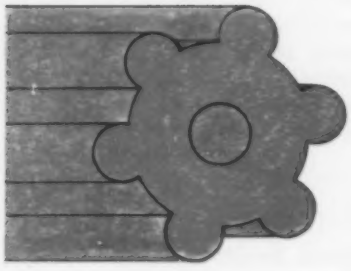
SYNTHANE

SYNTHANE CORPORATION, 4 RIVER ROAD, OAKS, PA.



Replace expensive heavy-duty bronze with low-cost Continuous-Cast Asarcon 773





Continuous-Cast ASARCON 773 Bronze (SAE 660) is a low-cost, readily available replacement for many "heavy-duty" bronze parts, especially where wear resistance is essential.

While sand-cast SAE 660 has a yield strength of 19,000 psi, the same alloy, continuously cast by ASARCO, has a yield strength of 27,000 psi.

How Continuous-Cast SAE 660 compares with sand-cast 80-10-10 and SAE 62 is shown in the table below:

Alloy	Tensile Strength	Yield Strength	Brinell Hardness
80-10-10 (Sand-cast)	35,000 psi	17,000 psi	62
SAE 62 (Sand-cast)	48,000 psi	20,000 psi	65
ASARCON 773 (SAE 660)	44,000 psi	27,000 psi	72

These extraordinary advantages in physical properties enable engineers to use ASARCON 773 in a variety of applications where more expensive alloys are now being specified . . . even aluminum and manganese bronzes under certain conditions.

ASARCON 773 has other important advantages for the designer to consider:

- It is available in rods, tubes and "extruded shapes" in diameters from ½ inch to 9 inches and in lengths up to 105 inches.
- Rods and tubes are stocked by a national organization of distributors who will cut the size you want to the exact length you need. Expensive short-end scrap is eliminated.
- It is more easily machined than most of the heavy-duty alloys it is used to replace.

ASARCO continuously casts many other bronze foundry alloys. If you want to know more about these unusual metals, call your nearest ASARCON distributor or write directly to us.

ASARCO

Continuous-Cast Products Department

AMERICAN SMELTING AND REFINING COMPANY

Perth Amboy Plant, Barber, New Jersey • Whiting, Indiana

WEST COAST SALES AGENT: Kingwell Bros. Ltd., 457 Minna Street, San Francisco

IN CANADA: Federated Metals Canada, Ltd., Toronto and Montreal

Shown Actual Size

Greater Sensitivity, Vibration Resistance *Engineered in* 'H' 'Diamond H' Relays

Continuing development of "Diamond H" miniature, hermetically sealed, aircraft type relays is constantly widening their performance range. Now, for example, in a 4 PDT relay: sensitivity to 85 mw with vibration resistance of 500 cycles at 10 "G" and 30 "G" shock resistance; vibration resistance of 55 to 2,000 cycles at 20 "G" with 50 "G" shock resistance and maximum sensitivity of 1½ watts.

Excellent contact reliability makes "Diamond H" relays preferred choice for critical jobs in vital applications ranging from guided missiles to high speed camera equipment.

TYPICAL PERFORMANCE CHARACTERISTICS

Vibration Resistance:	10-55 cycles at 1/16" double amplitude 55-500 cycles at 15 "G" 55-1,000 cycles at 15 "G" 55-2,000 cycles at 20 "G"
Temperature Range:	—55° to + 85°C. —65° to + 125°C. —65° to + 200°C.
Coils:	Resistances—1 ohm to 50,000 ohms Arrangements—single coil; two independent coils, either or both of which will operate unit
Insulation Resistance:	1,000 megohms at room temperature 100 megohms at 200°C.
Dielectric Strength:	450 to 1,250 V., RMS
Operating Time:	24 V. models 10 ms. or less; dropout less than 3ms.
Contacts:	30V., D.C.; 115V., A.C.; 2, 5, 7½ and 10A., resistive; 2 and 5A. inductive. Minimum 100,000 cycles life. Low interelectrode capacitance — less than 5 mmf. contacts to case; less than 2½ mmf. between contacts. Special Ratings: to 350 V., D.C., 400 MA., or other combinations including very low voltages and amperages or amperages to 20.
Operational Shock Resistance:	30, 40 and 50 "G" plus
Mechanical Shock Resistance:	up to 1,000 "G"
Mounting:	9 standard arrangements to meet all needs — plus ceramic plug-in socket.
Size:	1.6 cu. in.
Weight:	4 oz. or less

Call on "Diamond H" engineers to work with you in developing a variation to meet your specific requirements.

THE HART MANUFACTURING COMPANY
206 Bartholomew Avenue, Hartford, Connecticut

ators are available, basic pin-type, leaf, long-leaf, and leaf-roller types.

UL-listed at 5 amp, 125/250 v a-c, the switch is single-pole, double-throw. Unimax Switch Div., W. L. Maxson Corp., Ives Road, Wallingford, Conn.

For more information—
Circle 54, inside back cover

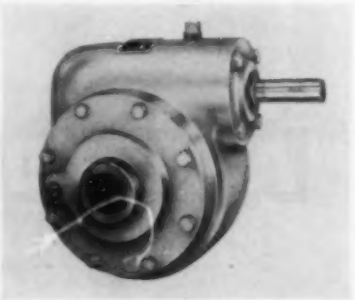
Soldering Iron for Printed Circuits

The iron weighs 1 oz, has an ⅛ in. tip, and is 7½ in. long. A thermostat controls heat so that excessive fusing and tip-burning are said to be eliminated. The unit is UL approved. It operates on 110-120 v a-c or d-c. Wall Mfg. Co., Grove City, Pa.

For more information—
Circle 55, inside back cover

Shaft-Mounted Speed Reducer

This worm gear reducer is offered in four basic sizes, with a selection of bores and ratios in each size. Case is made of heat-treated aluminum alloy. Radial shielded bearings are used on high speed shaft, and tapered



(Continued on page 249)

Idea Sparkers

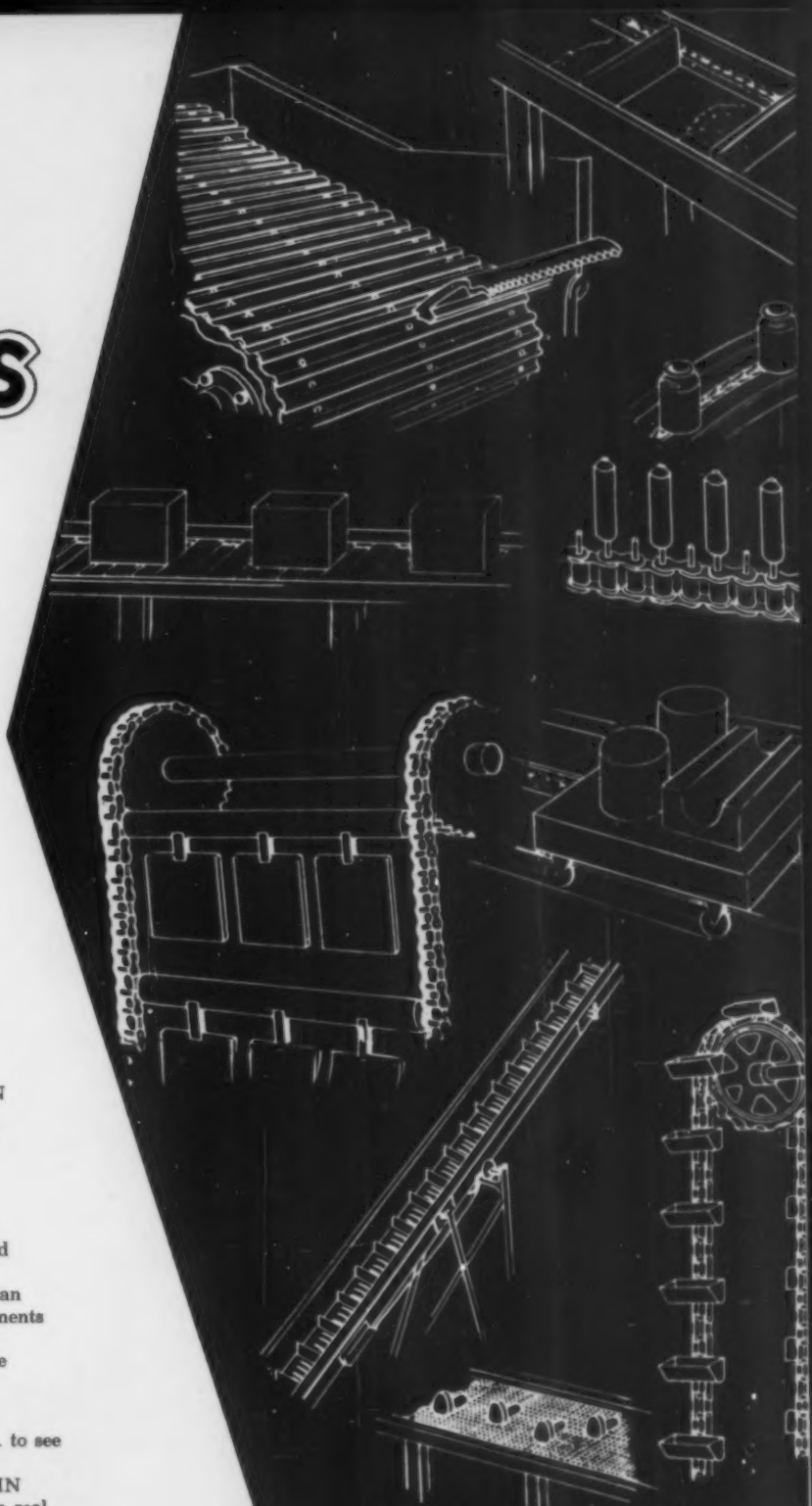
for

MATERIAL HANDLING

Ever been caught
"dead center" on design . . . just
needing a "spark" to trigger
the idea you need to get
going again?
Perhaps there's an idea here
for you . . . a different use of
chains and attachments that might
help you find a better, more
efficient way to move materials.

For example, in the complete CHAIN
Belt line, there are dozens of
different types of chain attachments
that can be used in hundreds
of different ways.
Bars, rods, slats, plates, tripping
mechanisms, pins, tabs and many
other devices can be simply fastened
to chain attachments to perform a
multitude of tasks. Many chains can
operate as conveyors without attachments
. . . using their surfaces as a carrier.
There are virtually no limits to the
things you can do with efficient
chain and attachments.

We'll be happy to work with you . . . to see
if we can come up with an idea that
can solve your problems. Your CHAIN
Belt District Sales Engineer can be a real
help to you, backed by our conveyor
chain engineers.



TURN THIS PAGE FOR MORE INFORMATION

CHAIN BELT COMPANY

LEADERSHIP . . . through creative engineering

IDEA SPARKERS *(CONTINUED)*

Why not send for informative literature on conveyor chains and attachments? You'll be amazed at ideas you'll get just from looking over the many attachments you probably never dreamed existed. Just mail the coupon below. There is no obligation.

REX

CONVEYOR CHAINS AND ATTACHMENTS

Rex Roller Chain with a K-1 attachment

Rex Roller Chain with a D-3 attachment

Rex Roller Chain with an M-3 attachment

Rex Double Pitch Roller Chain with an M-2 attachment

Rex Double Pitch Roller Chain with a D-1 attachment

Rex Chabelco Steel Chain . . . best where loads are heavier or where operating conditions are severe.

Rex 9250 Chain . . . for carrying boxes, cartons, large cans. Will flex in two planes. Made in wear-defying Rex Z-Metal.

Rex TableTop Chain . . . a flat, level carrying surface, ideal for cans, bottles, jars, small parts and packages.

SELF-ALIGNING ROLLER BEARINGS

For effective protection of equipment . . . for longer service life at lower power costs, investigate Shafer Self-Aligning Roller Bearings. Combining all the advantages of ball and roller bearings, these efficient units are your best choice for economical service.

CHAIN Belt Company
Dept. DP-3
Milwaukee 1, Wis.

☐ Send me informative literature on Rex Conveyor Chains and Attachments.
☐ Have my CHAIN Belt District Sales Engineer call.

NAME .....
COMPANY .....
ADDRESS .....
CITY..... ZONE..... STATE.....

CHAIN BELT COMPANY
MILWAUKEE 1, WISCONSIN

roller bearings on low speed shaft.

Worms are cut on steel alloy shafts. Gears are made of gear bronze. Mechanical lip type seals are mounted on shafts which are both ground and honed for close finishes. Electra Motors, Inc., Anaheim, Calif.

For more information—
Circle 56, inside back cover

Printed Circuit Connectors

The receptacles are available for circuit boards $\frac{1}{16}$ to $\frac{1}{8}$ in. thick. Microdot, Inc., 1826 Fremont Ave., S. Pasadena, Calif.

For more information—
Circle 57, inside back cover

High Velocity Liquid Spring

This self-contained device includes a high velocity liquid spring for use where tremendous energy is required instantaneously. Of the $\frac{3}{4}$ in. stroke, 90 per cent is a spring and the last 10 per cent acts as a shock absorber to stop the high velocity piston without structural damage. High velocity output can be used to accelerate a mass and high impact cushioning action

(Continued on page 252)

New ULANET FM Thermostats protect and control machines, equipment and processes—

SPECIAL HIGH TEMPERATURE STRAIN RELIEF PROTECTED LEAD WIRES

Rapidly respond to extremely close temperature variations in:

LIQUIDS, SOLIDS, GASES, HEATED SURFACES AND AMBIENT TEMPERATURES

RATING
1200 WATTS
115-230 VOLTS ac

TEMPERATURE RANGE
0° to 600° F.

- EASY TO ADJUST OR SET BY ACCESSIBLE SELF-LOCKING ADJUSTMENT SCREW
- VIBRATION AND SHOCK RESISTANT
- COMPLETELY SEALED
- PROVED IN SERVICE

Two of the exclusive features of the Ulanet FM Thermostats are:

1. The complete lack of reliance on the expansion of the outer shell for make and break of contacts. This permits greater mounting flexibility and freedom from erroneous operation when clamped or when slight pressure might be applied to the outer shell during use.

2. Lead wires are mechanically strain relief protected to prevent external movement of the wire from being transferred to the contact members in the enclosure.

The relatively low cost and stamina of these units merits your immediate further investigation. Ulanet engineers will be glad to consult regarding specific applications.

RUGGED . . . SENSITIVE . . . COMPACT

25 Years Heat Control Experience

SINCE 1931
ULANET
ELECTRIC HEAT CONTROL ENGINEERS

GEORGE ULANET COMPANY
Thermostats, Thermal Timers
414 MARKET ST. NEWARK, N. J.

GOLD N RING

Units are available in flush-plate or enclosed mountings, and are adaptable for special panel assemblies.

New...

Oil-tight • Water-tight • Dust-tight

Protected against oil and water seepage by Sealtight oil-resistant rubber diaphragm. Rated for 600 volts, AC or DC. Meets requirements of Joint Industry Committee and National Machine Tool Builders' Association.

EASILY REPLACES EXISTING SWITCHES — Designed for mounting in 1 3/64" diameter holes on standard panel mounting centers, this switch easily replaces existing switches. Accommodates panel thicknesses of 1/16" to 1/4" in 1/32" increments. Full interchangeability of units and their components permits ready adaptation to multiple assemblies.

Another product of...

National Acme

Sealtight CONTROL SWITCH

Made by machine tool builders to machine tool specifications

How often have you, when designing a machine tool, wished for a control station unit designed and constructed "*as a machine tool builder would build it.*"

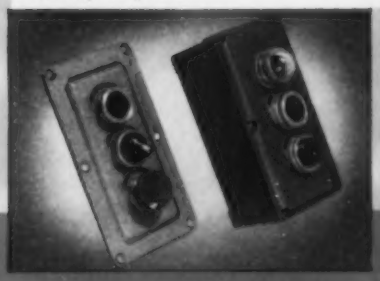
If you have been so handicapped in the past, you'll want to take a good close look at the NEW Namco GOLD-N-RING Control Station Switch Unit. Built by National Acme, builder of the world's only complete line of bar and chucking automatics, it is the *only* switch made *by* a machine tool builder *with machine tool know-how behind it.*

- **It is a heavy-duty switch in every respect.**
- **It is oil-tight, water-tight, dust-tight.**
- **Heavy-duty silver-alloy contact points provide maximum electrical capacity and long life.**
- **Heavy-duty terminal screws, with ⅜" thread contact, prevent stripping during installation and permanently secure wires for continuous trouble-free service.**
- **None easier to install; none more fool-proof.**

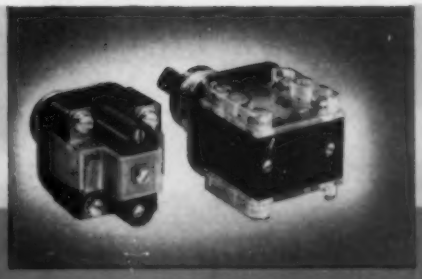
For complete details, send for Bulletin ECS-56. Better yet, ask for a representative to bring a switch for your examination.

Electrical Mfg. Division • THE NATIONAL ACME COMPANY • Cleveland 8, Ohio

▼ **FLUSH PLATES OR ENCLOSURES** accommodate any combination of individual push button, selector or pilot light assemblies. Box covers and flush plates are provided with captive screws to facilitate installation. Easy-to-read, interchangeable legend plates lock securely into position.



▼ **SINGLE AND DOUBLE POLE CONTACT BLOCKS** can be used interchangeably with the several types of GOLD-N-RING push button and selector operator heads. Design provides easy access for secure wiring (or use of stake-on lugs) without interference. Fixed and movable contacts are completely enclosed by heavy plastic shields.



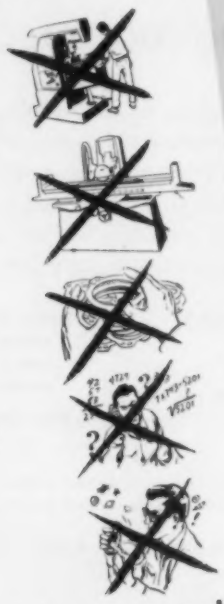
▼ **BRASS INSERTS** molded in block permanently hold stationary contacts. They also provide more thread support for the No. 8-32 terminal screws that are equipped with captive flat and lock type washers.

▼ **BUILT AS A MACHINE TOOL BUILDER WOULD BUILD IT!** Plastic shields (A) completely enclose contacts. Main block (B) is unit-molded to assure alignment and simplify assembly. Fully guided plunger (C) of cross-head design, prevents binding. Oil-resistant rubber diaphragm in operator head (D) completely seals out oil, water and dust. Easy-to-read legend plates (E) lock into position by "GOLD-N-RING" (F).

▼ **INTERCHANGEABLE "GOLD-N-RING" COLLARS** come in 3 different heights. Buttons can be made either extended or flush type merely by changing collar. Buttons are of non-fading glass-filled polyester and come in an assortment of colors to conform with standard codes.

MESSAGE from the "NO" men of Laminated Shim Company

You lose **NO** time when you use LAMINUM SHIMS...



NO machining!

NO grinding!

NO counting!

NO stacking!

NO miking!

...and **NO** dirt between layers—ever!

LAMINUM®
SURFACE BONDED... THEY peel FOR ADJUSTMENT

Laminated Shims of LAMINUM now available in

STAINLESS STEEL with laminations of .002" or .003"	ALUMINUM with laminations of .003" only
BRASS with laminations of .002" or .003"	LOW CARBON STEEL with laminations of .002" or .003"

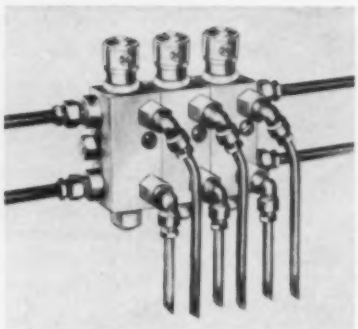
LAMINATED SHIM COMPANY, INC.
Shim Headquarters since 1913
1410 Union Street, Glenbrook, Conn.

can be used to decelerate a mass without impact loading.

The spring develops 6400 lb spring action on a ¾ in. stroke with a preload of 1000 lb and provides 10 in-lb of shock absorption, while at the same time providing 200 in-lb of high velocity energy output with a total efficiency of 77 per cent.

This liquid spring is 1¼ x 8 in. long and has a bearing surface on each end to facilitate reciprocation of the spring body if it is desired to use the cylinder as a reciprocating mass. Taylor Devices, Inc., 188 Main St., N. Tonawanda, N. Y.

For more information—
Circle 58, inside back cover



Lubrication Cycle Counter

This counter registers the number of times that the lubricant valve is discharged. The unit, furnished as a kit, can be installed without removing valves from the system for which it was designed. It provides a permanent operational record of each valve. The unit screws into the valve and extends 1⅝ in. above it when in operation. Alemite Div., Stewart-Warner Corp., 1826 Diversey Pkwy., Chicago 14, Ill.

For more information—
Circle 59, inside back cover

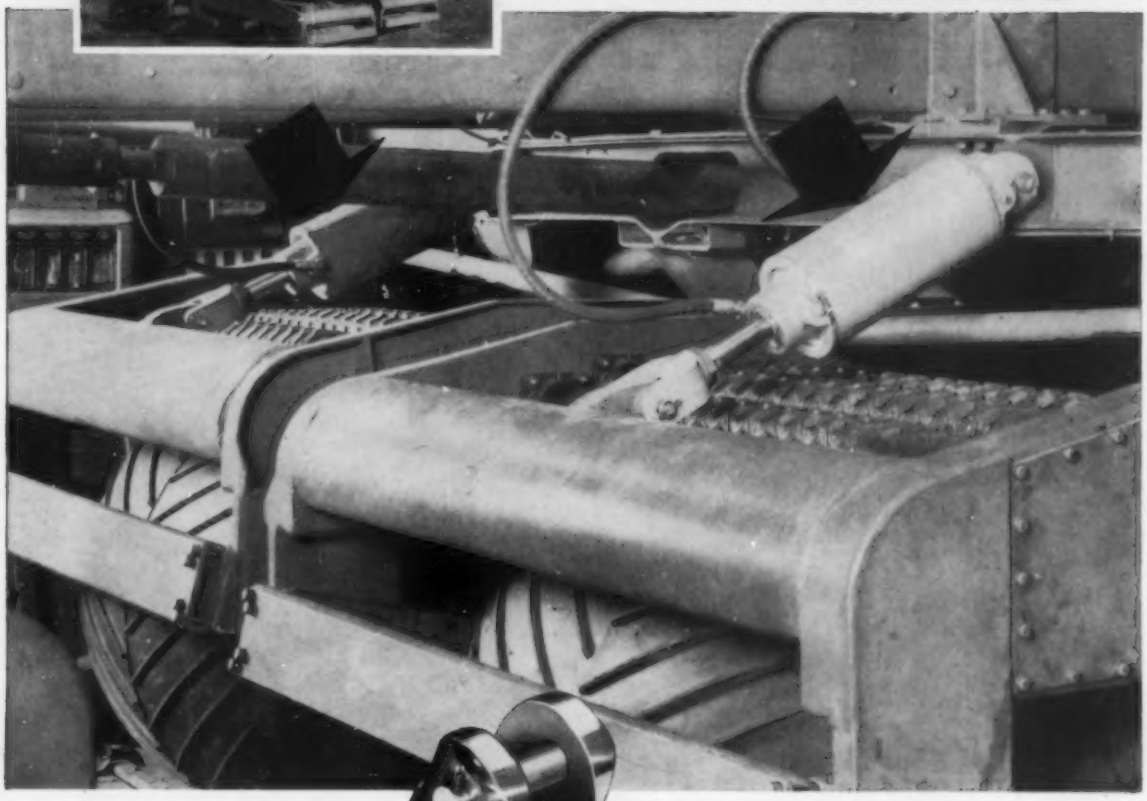
Press-fit Teflon Terminals

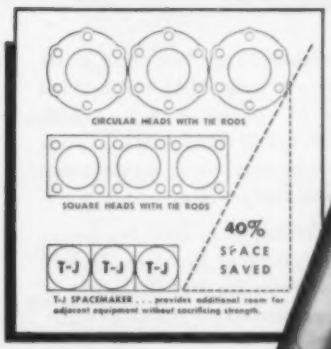
With dielectric strength ranging from 1000 to 2000 v per mil thickness, these terminals can be spaced ¼ in. between centers. Each feed-thru terminal has turret lugs for inside and outside wrap-around and soldered connections.

These terminals are available in

(Continued on page 255)

Arctic Cargo Carrier Depends On T-J *Spacemaker* CYLINDERS




CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
40% SPACE SAVED
T-J
T-J
T-J
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

Saves 40% Space!
No Tie Rods For Greater Strength

Differential axle loading through T-J Spacemaker Air Cylinders forms a controlled walking beam in this Teracruiser, designed and produced for the Army Ordnance Corps by the Four Wheel Drive Co., Clintonville, Wis.

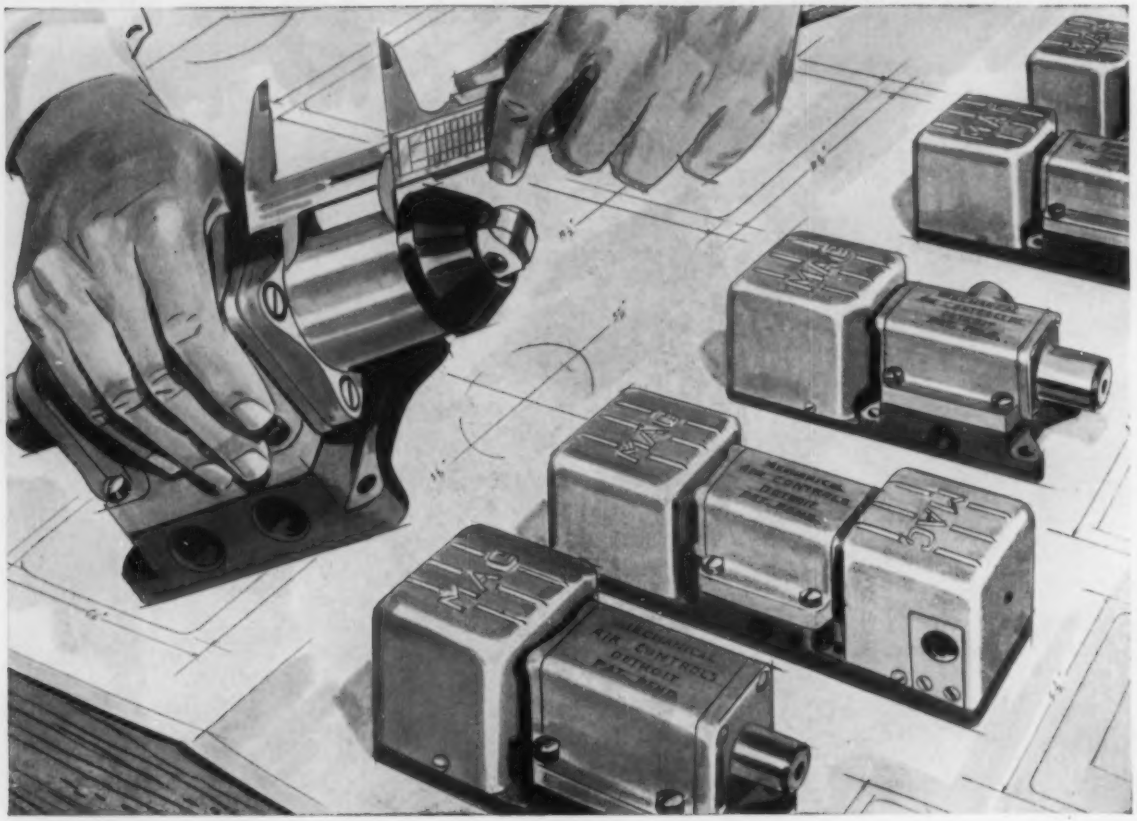
Weight of cylinders was important factor in choosing T-J Spacemakers, which reduce weight while providing same displacement and extra high safety factor. Fast delivery and space-saving features also favored T-J. Exclusive with T-J are new Super Cushion Flexible Seals for Air (to 200 P.S.I.) . . . and New Self-Aligning Master Cushion for Oil (to 750 P.S.I.). Hard chrome plated bodies and piston rods are standard, at no extra cost. Wide range of styles, capacities . . . 64,000 combinations *off the shelf!* Write for bulletin SM-155-3. The Tomkins-Johnson Co., Jackson, Mich.

ALL MODELS . . . OFF SHELF DELIVERY

MEETS WITH ALL JIC RECOMMENDATIONS

T-J TOMKINS-JOHNSON
RIVETORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

QUALITY IS STANDARD . . . RIGHT DOWN THE LINE



If you walked into our plant you'd hear the rhythm of air valves . . . see machines and men—*just testing!* They're the "fault-finders"—methodically inspecting each MAC valve . . . checking alignment and bore precision . . . hunting a defect in a spring, a faulty solenoid or an imperfect seal. The slightest flaw brings a quick reject. For at MAC we're building *reputation* as well as valves. We make high quality standard on all 98 models.

You'll find MAC valves outstanding, too, for dependability, performance *and value.* They're lighter, more compact, have fewer parts to wear. MAC's simplified design assures millions of operating cycles — with little, if any, maintenance. Small wonder MAC valves are showing up on more and more equipment at tool shows, in shops and plants, *everywhere.*

Why not contact us? We're happy to lend our know-how to any air valve application or problem. There's no obligation, of course. Write for free literature or call one of the MAC representatives listed at right.

MECHANICAL AIR CONTROLS, INC.
10030 Capital, Oak Park, Detroit 37, Michigan

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ILLINOIS
CHICAGO 43—Mike C. Modrich & Co., 10336 South Western Ave., Hilltop 5-3640

INDIANA
FORT WAYNE 3—Neff Engineering Co., P. O. Box 2001, Station A, 2339 Crescent Ave., EAstbrook 7391
INDIANAPOLIS 20—Neff Engineering Co., P.O. Box 7361, 42nd St. Station, BRoadway 2330
SOUTH BEND—Dick Futter, 103 South Varsity Dr., CEntral 2-4856

MARYLAND
BALTIMORE 6—Grand Air-Hydro Division, K. William Ostrom & Co., Inc., 6105 Alta Ave., HAmilton 6-6669

MASSACHUSETTS (and New England)
BOSTON 34—Electrical Apparatus Co., Inc., 1200 Soldiers Field Rd., STadium 2-7440

MICHIGAN
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FLINT—Kober Sales Engineering Co., 514 Beach St., CEdar 8-5123
GRAND RAPIDS—Fred McAvoy, 190 Monroe N.W., GLendale 6-1321

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ST. PAUL 14—W. H. Schulz Co., 2438 Franklin Ave., MIdway 4-2791

MISSOURI
ST. LOUIS COUNTY—Oscar E. Jost Co., P. O. Box 6, St. Ann, HArrison 8-4488

NEW JERSEY (Northern)
CRANFORD—The Roden Company, P. O. Box 305, CRanford 6-7330

NEW YORK
BUFFALO 21—C. H. Tepas Co., 200 Washington Hwy., Circle 3210
NEW YORK CITY—J. Neill Armstrong, Inc., 545 Fifth Ave., MUrray Hill 7-6865

OHIO
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TEXAS
DALLAS 18—Womack Machine Supply Co., Shea Rd. at 7200 Harry Hines, DIxon 6997

WASHINGTON
SEATTLE—The Rucker Co., 101 Jones Bldg., Rm. 203, MAin 2783

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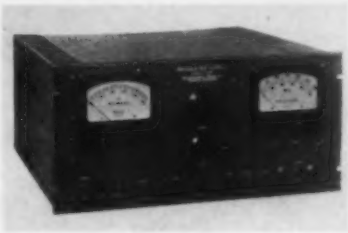
eight RETMA color-code colors — white, brown, yellow, blue, red, orange, green and gray. Available in both standoff and feed-thru designs, in miniature and subminiature sizes. Sealectro Corp., 610 Fayette Ave., Mamaroneck, N. Y.

For more information—
Circle 60, inside back cover



High Current D-c Power Supply

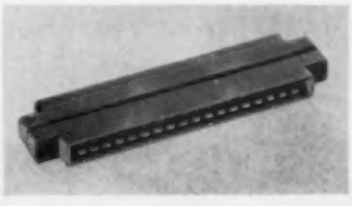
A 1½-amp unit, response is 0.4 millisec no-load to full load, 0.25 millisec full load to no-load. The power supply provides 0 to 300 v d-c at 1½ amp, continuously variable without switching. It supplies a variable bias voltage of 0 to 145/155 v d-c at 5 ma, and an external 6.3 v a-c output at 10 amp. High voltage output is floating, and may be used as either a positive or negative source.

The supply fits a standard 19 in. relay rack, and is 8¾ x 17 in. deep. Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena, Calif.

For more information—
Circle 61, inside back cover

Printed Circuit Feed Through Connectors

The solder lugs of two printed circuit receptacles are permanently soldered together to form a single feed-through connector which accommodates a printed circuit board on each side. This unit is available in 6, 10, 15, 18 and 22 contacts (single or dual)



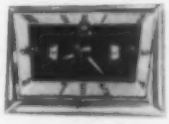
(Continued on page 258)

When Timing is the Problem . . . Look to LUX

LUX . . . specialists in the industrial timing field and producers of over 20 million clocks and timers . . . now offers the full facilities of their renowned laboratories to help solve your timing problems.

For design engineering assistance . . . cooperation on custom-developing and adapting of electric or mechanical timing devices to meet your specialized needs . . . contact LUX.

TYPICAL PRODUCTS DEVELOPED BY THE FAMOUS TIMING LABORATORIES OF LUX



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TIMERS FOR ELECTRIC DRYERS

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- AIR CONDITIONERS
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LUX Time

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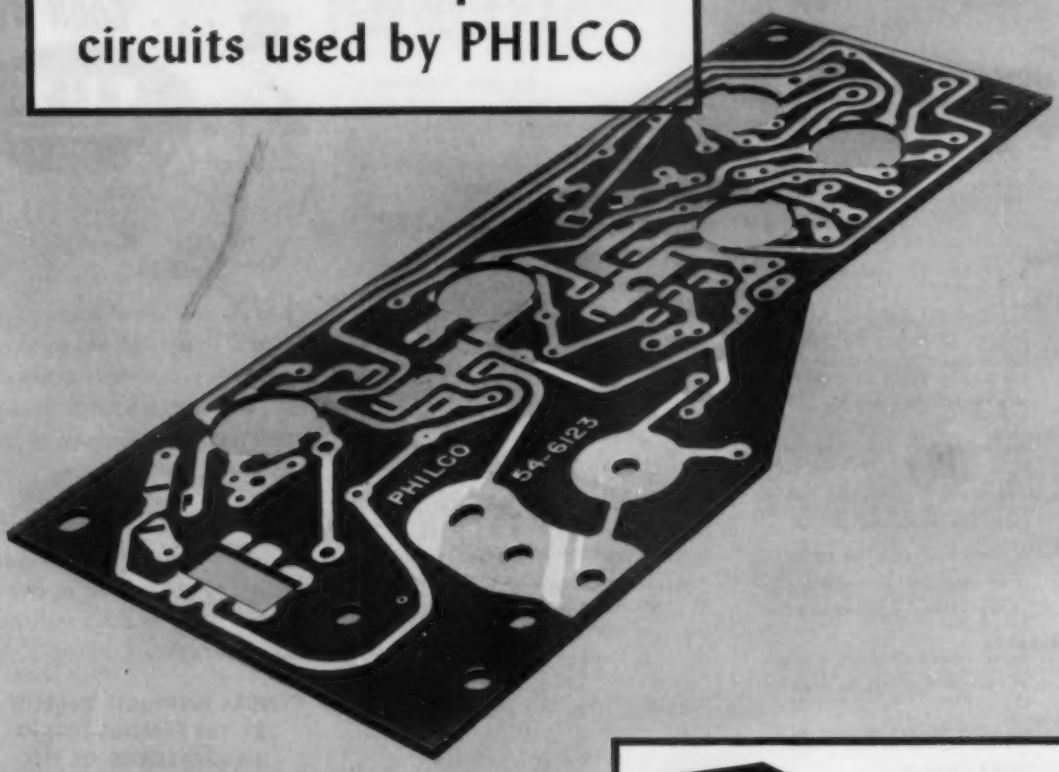
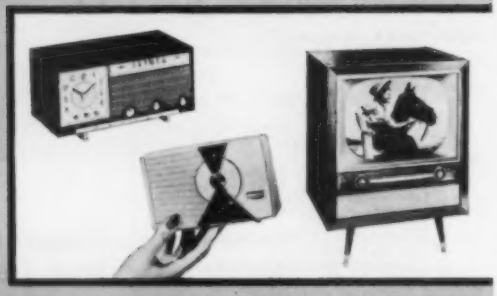
The LUX CLOCK MANUFACTURING CO., Inc.
WATERBURY 20, CONNECTICUT

INSUROK® T-725 printed circuits used by PHILCO





Philco design and production engineers are using Richardson Copper-Clad INSUROK T-725 laminate for printed TV and radio circuits.

Examples are Underwriters approved assemblies for Philco's 21" console TV, Philco's five tube table radio and Philco's transistorized portable radio. All use INSUROK T-725 printed circuits.

In the manufacture of printed circuit materials, the most important single consideration is the laminate. Richardson, a pioneer in the development of printed circuit laminates, has the necessary experience and know-how. Copper-Clad INSUROK T-725 is a laminate of outstanding excellence . . its electrical qualities remain remarkably stable under repeated temperature and humidity cycling.

For further information, write or phone today . . Chicago number, MAnsfield 6-8900.

founded 1858

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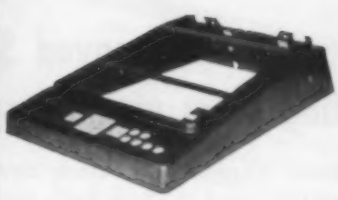
THE RICHARDSON COMPANY
2797 Lake St., Melrose Park, Ill.

T & W Technique produces forgings meeting severe requirements, like this 30-inch, 242 lb. drive shaft for a crawler tractor.



This radar unit base, deep drawn from 16 gage steel, 7" x 18" x 24", is an example of what *T & W Technique* can accomplish in stampings.

How to put the POWER of T&W TECHNIQUE behind your cost reduction efforts

● You can concentrate outstanding engineering, organizing, and production facilities on your problem of cost reduction by making use of *T & W Technique*. Starting with design, and following through to delivery, *T & W Technique* is the coordination of a great organization to furnish you forgings and stampings so the, ost you less at your point of assembly. Find out now what our special methods and services can do for *you*. Send the coupon today.

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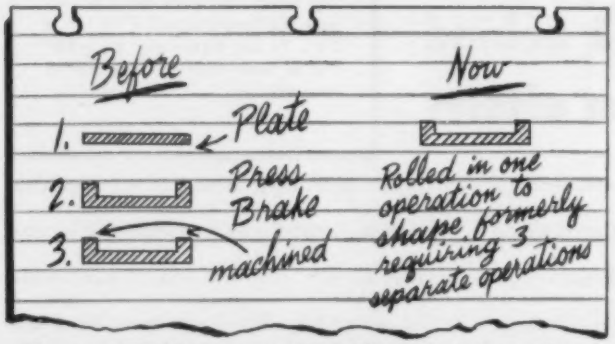
T & W DEEP DRAWN STAMPINGS AND FORGINGS USUALLY COST LESS AT THE POINT OF ASSEMBLY

CLARK® EQUIPMENT reduced operation time 66%...

...and saved $1.34 a foot by using west virginia special sections

West Virginia and Clark developed the special section used in Clark truck uprights 10 years ago. This effected a savings of time and money.



Now, on Clark's new machine, West Virginia sections give ultimate strength along with economy. Maybe a West Virginia engineer can do the same for you?

Write or Call for **FREE ENGINEERING CONSULTANT** *Service!*

west virginia steel

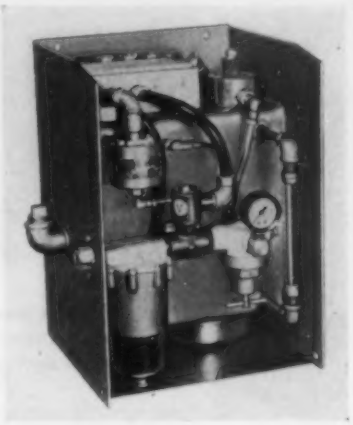
and MANUFACTURING COMPANY

P. O. Box 316 Huntington, West Virginia

with molding compounds of mineral-filled Melamine or Plaskon-reinforced Alkyd 440A.

The contacts accommodate a printed circuit card thickness of 0.051 to 0.071 in. Overall depth of the combined connector is 0.86 in. DeJur Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

For more information—
Circle 62, inside back cover



Oil-Mist Lubricators

Continuous lubrication for up to 300 or 500 bearing inches of lubricated mechanisms is provided whether in a compact installation or extended over a distance of 400 ft. Alemite Div., Stewart-Warner Corp., 1826 Diversey Parkway, Chicago 14, Ill.

For more information—
Circle 63, inside back cover

Sealed Snap-Action Switch

A silicone boot seals the clearance space around the operating pin, and the cover is sealed with the base, using a thermosetting resin. The switch

(Continued on page 262)

a young production engineer finds a new way to cut costs

Production Scheduling

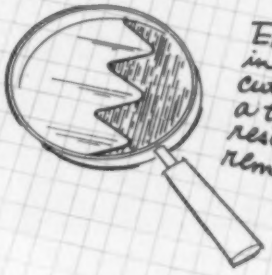
Why do we waste time and money on tapping?

Just drill and drive!
No tap--no tap maintenance!

There are 3 types!

Type I for metals
Type 23 for metals and plastics
Type 25 for plastics
ALL CAN BE HOPPER-FED!

SHAKEPROOF® Thread Cutting Screws have a specially designed slot that cuts its own thread with true tapping action.



Each screw remains in the thread it has cut itself... assures a tight, vibration-resistant fit. Can be removed and re-used if desired

So specify **SHAKEPROOF**® Thread-Cutting Screws and you--
Eliminate Tapping
Speed Assembly
Cut Costs

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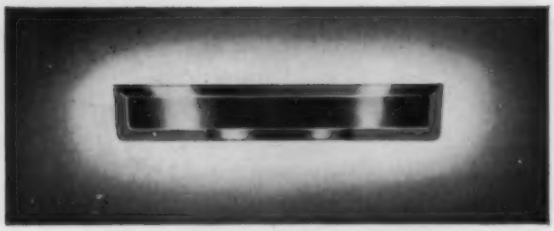
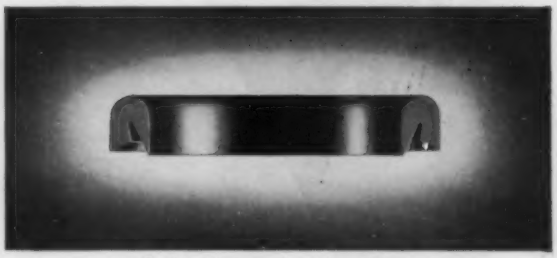
DIVISIONS OF ILLINOIS TOOL WORKS
World's Broadest Line of Mass-Assembly Fastenings

Simplify your sealing problems...

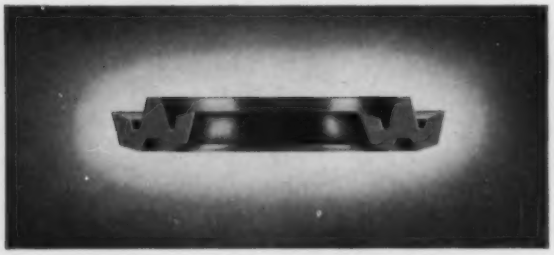
with Johns-Manville Precision moulded packing designs for pressure applications in hydraulic and pneumatic equipment



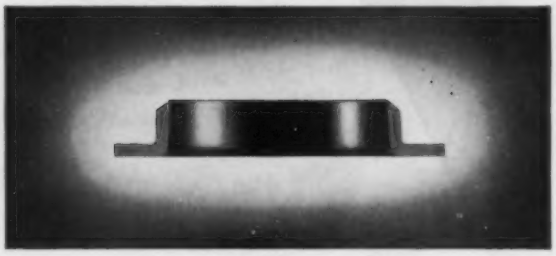
1. Type "A" Packing Cups for pistons
(the original "square heel" cup design)



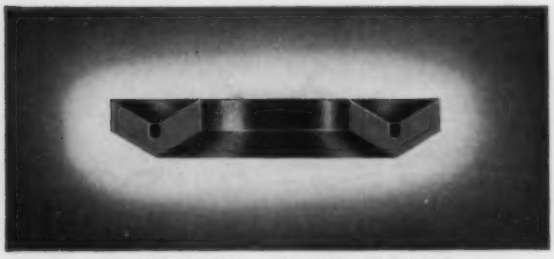
2. Sea Ring packing for rods



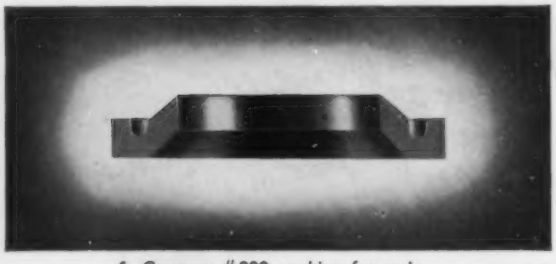
3. Uneepac Packing for rods and pistons



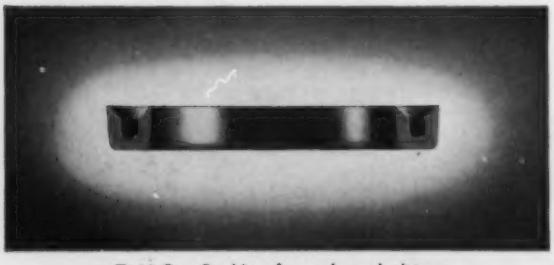
4. Hat Cup Packing for rods



5. V-Rings packing for rods and pistons



6. Cumpac #239 packing for rods



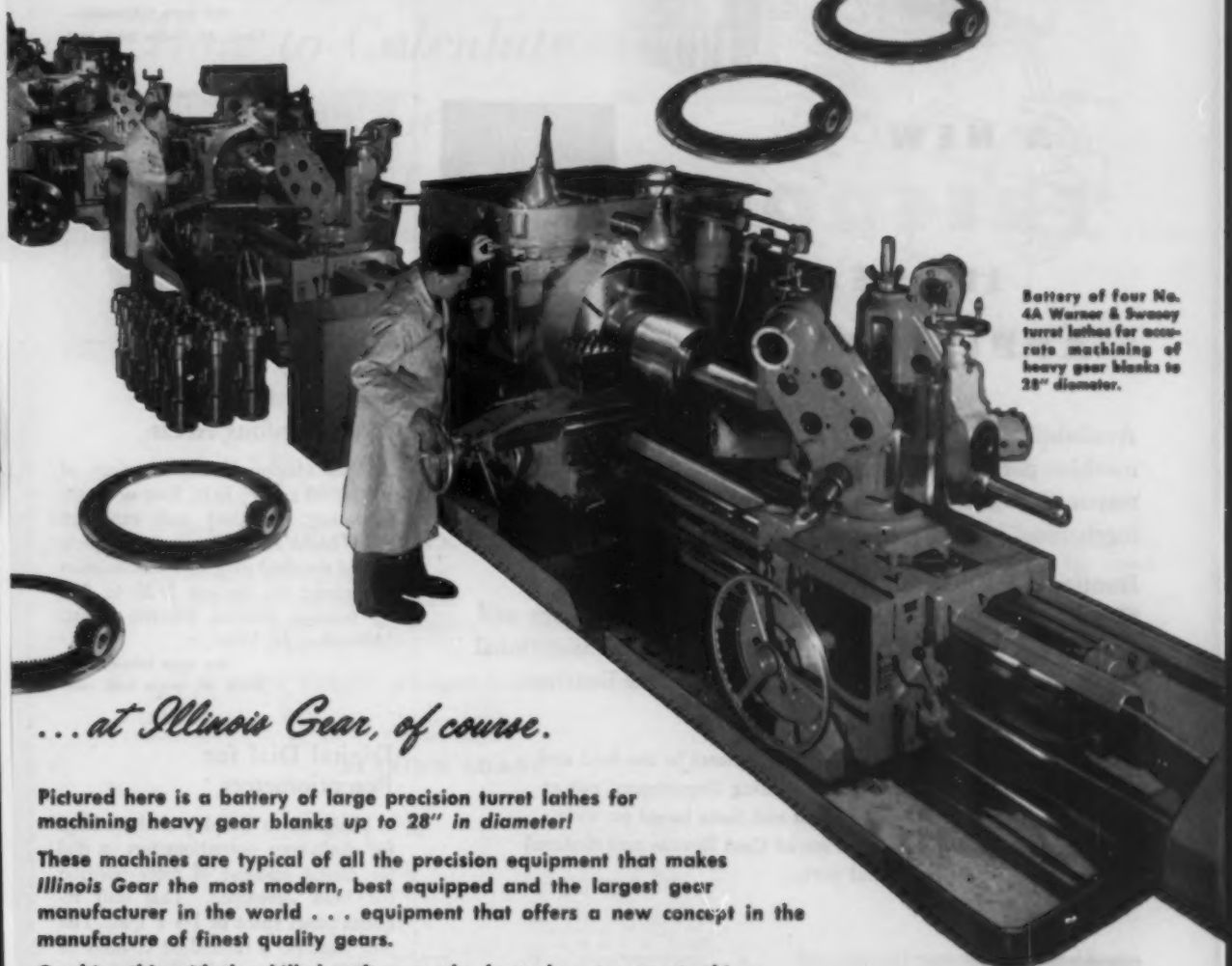
7. U-Cup Packing for rods and pistons

THE WIDE VARIETY of Johns-Manville Packing designs enables you to handle practically any sealing problem. The designs shown on this page are obtainable in a broad range of standard sizes and in materials designed for either usual or special service conditions encountered in hydraulic and pneumatic equipment. Johns-Manville also produces oil seals, moulded gaskets and miscellaneous shapes to specification. See your local J-M distributor or J-M sales office for product or engineering data. Or write Johns-Manville, Box 14, New York 16, N.Y. In Canada, Port Credit, Ontario.

JM PRODUCTS

Johns-Manville MOULDED PACKINGS

Where on earth will you find such machinery...



Battery of four No. 4A Warner & Swasey turret lathes for accurate machining of heavy gear blanks to 28" diameter.

...at Illinois Gear, of course.

Pictured here is a battery of large precision turret lathes for machining heavy gear blanks *up to 28" in diameter!*

These machines are typical of all the precision equipment that makes *Illinois Gear* the most modern, best equipped and the largest gear manufacturer in the world . . . equipment that offers a new concept in the manufacture of finest quality gears.

Combine this with the skilled craftsmen who *know how* to operate this equipment and you have the reason why *Illinois Gear* can produce gears that measure up to your most demanding specifications . . . why *Illinois Gear* can make and fulfill delivery promises.

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Bunting facilities for designing, engineering and manufacturing of Sintered Powdered Metal Bearings and parts are as comprehensive and responsible as the traditional Bunting competence in the field of Cast Bronze Bearings.

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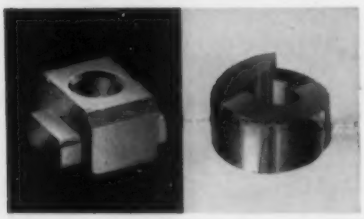

Write to our Product Engineering Department in Toledo or consult our nearest Sales Engineer.

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS
OF CAST BRONZE AND POWDERED METAL

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is available with a variety of actuators. It is UL-listed for operation at 20 amp, 125, 250 and 480 v a-c; also 0.25 amp, 250 v d-c, and 0.50 amp, 125 v d-c. W. L. Maxson Corp., Ives Road, Wallingford, Conn.

For more information—
Circle 64, inside back cover

Magnetic Brake for Hazardous Areas

With maximum torque ratings of 10, 25, 50 and 75 lb-ft, floor or motor mounting, the dust and explosion proof brake supplements a complete line of standard magnetic transmission equipment for use on 1/20 to 100 hp motors. Stearns Electric Corp., Milwaukee 46, Wis.

For more information—
Circle 65, inside back cover

Digital Dial for Potentiometers

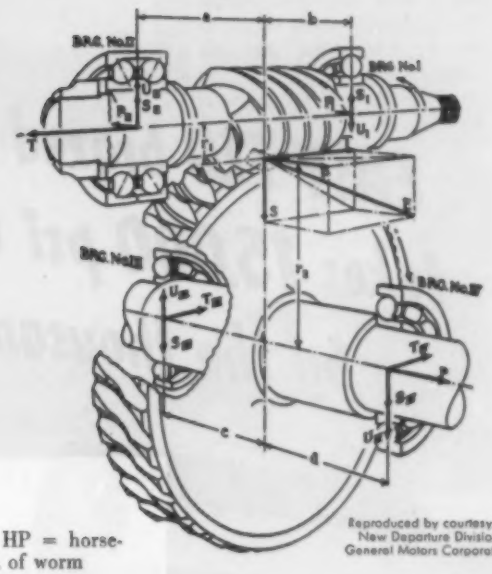
Designed to simplify dial readings for multi-turn potentiometers, a dial for digital read-out of rotor position has been developed. This unit requires panel space of 1⅞ x 1 in. The unit contains a three-digit counter (0 to 999), with provision for mounting on the drive-shaft of a ten-turn potentiometer. Detenting in ½ digit in-

(Continued on page 264)

(Advertisement)

Helpful Data from
DE LAVAL

How to Calculate Worm Gear Bearing Loads



Reproduced by courtesy of New Departure Division General Motors Corporation

$Q = \dfrac{HP \times 63025}{N}$ = TORQUE INPUT to worm, lbs. inches; HP = horsepower transmitted and N = rev. per min. of worm

$P = \dfrac{Q}{r_1}$ = TANGENTIAL FORCE of worm, where

r_1 = Pitch radius of worm in inches
[r_2 = Pitch radius of worm gear
$= \dfrac{1}{2\pi}$ (number of teeth in gear x axial worm pitch)]

$S = \dfrac{P \tan \alpha}{\tan \gamma}$ = SEPARATING FORCE, where

α = Axial tooth pressure angle*

γ = Helix or lead angle of worm*

$= \tan^{-1} \dfrac{\text{lead}}{2\pi r_1}$, or $\tan^{-1} \dfrac{\text{Number of threads x axial worm pitch}}{2\pi r_1}$

$T = \dfrac{P}{\tan \gamma}$ = WORM THRUST, or tangent force driving worm gear

* LEAD ANGLE 0°-35° use 27½° Pressure Angle
LEAD ANGLE 35°-45° use 30° Pressure Angle

BEARING LOADS

Due to	on Brg. I	on Brg. II
P	$P \dfrac{a}{a+b} = P_I$	$P \dfrac{b}{a+b} = P_{II}$
S	$S \dfrac{a}{a+b} = S_I$	$S \dfrac{b}{a+b} = S_{II}$
T	$T \dfrac{r_1}{a+b} = U_I$	$T \dfrac{r_1}{a+b} = U_{II} = U_I$
Total Rad. Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{P_{II}^2 + (S_{II} + U_{II})^2} = R_{II}$
Thrust Load		T
Total Load	$\sqrt{P_I^2 + (S_I - U_I)^2}$	$\sqrt{R_{II}^2 + T^2}$

Due to	on Brg. III	on Brg. IV
P	$P \dfrac{r_2}{c+d} = U_{III}$	$P \dfrac{r_2}{c+d} = U_{IV} = U_{III}$
S	$S \dfrac{d}{c+d} = S_{III}$	$S \dfrac{c}{c+d} = S_{IV}$
T	$T \dfrac{d}{c+d} = T_{III}$	$T \dfrac{c}{c+d} = T_{IV}$
Total Rad. Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{T_{IV}^2 + (S_{IV} + U_{IV})^2} = R_{IV}$
Thrust Load		P
Total Load	$\sqrt{T_{III}^2 + (U_{III} - S_{III})^2}$	$\sqrt{R_{IV}^2 + P^2}$

Speed Change

$$\text{Gear rpm} = N \times \frac{\text{Number of threads in worm}}{\text{Number of teeth in gear}}$$

For simplicity in bearing load computations for worm gearing, the normal tooth force E is treated in terms of its three perpendicular elements, namely, P, the tangential driving force at pitch radius of worm; S, the force tending to separate worm from the gear, due to the pressure angle; and T, the thrust produced by the lead or helix angle of the worm.

If you have a problem in the selection or application of worm gearing, De Laval engineers will be glad to put their experience to work for you. Either write us giving complete details, or consult your local De Laval representative.
De Laval Steam Turbine Company,
801 Nottingham Way,
Trenton 2, New Jersey

BL 848

crements allows digital read-out to one part in 2000. W. L. Maxson Corp., 47-57 Austell Pl., Long Island City 1, N. Y.

For more information—
Circle 66, inside back cover

Digital Ohmmeter

Range of the instrument is from zero to 9.999 magohm with minimum resolution of 10 ohm. Sampling rate is 60 cps; response, 1 sec (average); and accuracy is ±0.1 per cent of measured resistance or one digit, whichever is greater. Weighing 40 lb, this ohmmeter is available in rack mount and portable styles. Non-Linear Systems Inc., Del Mar Airport, Del Mar, Calif.

For more information—
Circle 67, inside back cover

Motors for Farm Applications

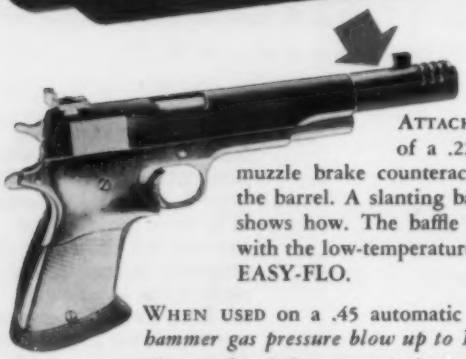
Two single-phase motors designed from test information and actual farm installations have been introduced. The repulsion-induction motor has brushholder parts of aluminum, copper and stainless steel or bronze. A built-in, manual reset, thermal overload protector prevents burnouts. The motor is manufactured in sizes from 1 to 7½ hp and is recommended for duty on silo unloaders, barn cleaners, milking machines, feed grinders, ensilage cutters, elevators, conveyors and other farm applications. The capacitor motor is best suited for applications where equipment operates continuously 24 hr per day. The motor is recommended for duty on ventilating

(Continued on page 268)

EASY-FLO brazed baffle takes 15,000 psi wallops by the thousands!

The LEE "muzzle brake" is proof positive of EASY-FLO brazing's amazing strength and ability to take it.

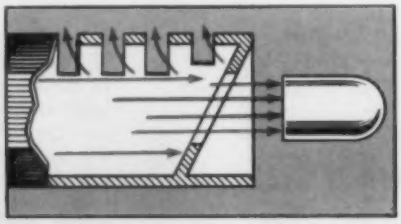
EASY-FLO BRAZED SLANTING BAFFLE



LFE Muzzle Brakes are made by LEE MFG. CO. Wheelwright, Mass.

ATTACHED to the business end of a .22 or .45 automatic, the muzzle brake counteracts the upward kick of the barrel. A slanting baffle does it. The sketch shows how. The baffle is brazed in the brake with the low-temperature silver brazing alloy — EASY-FLO.

WHEN USED on a .45 automatic the baffle takes a *trip-hammer gas pressure blow up to 15,000 psi at every shot.* Thousands of these muzzle brakes are in use, mainly by "target shooters" which means that most of them are subjected to the terrific shock of discharge thousands of times a year. Yet, in the more than 2 years these brakes have been on the market, not a single failure has been reported.



Gas pressure hitting the slanting baffle exerts a downward force that cuts the muzzle jump of a .45 automatic over 50%.

PUT EASY-FLO BRAZING INSURANCE IN YOUR METAL JOINING...

BULLETIN 20 tells why EASY-FLO brazing insures joints in both ferrous and non-ferrous metals that are *virtually indestructible* — also why EASY-FLO brazing is surprisingly fast and economical. Write for a copy today.

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General Offices: 82 Fulton St., New York 38, N. Y.

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When ordering, specify ¼", ⅜" or ⅜" tubes. Style TF.

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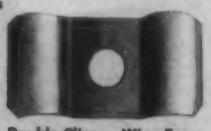
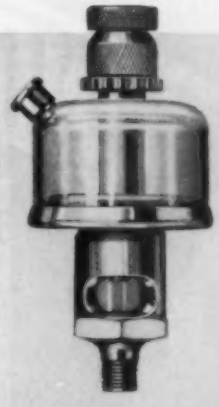
Double Clips

3-Tube Clips

4-Tube Clips



Double Clips — Wing Type

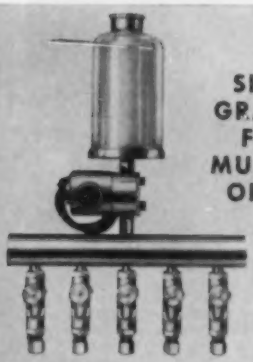


SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES

This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.



SIGHT GRAVITY FEED MULTIPLE OILERS

This one unit replaces 3 to 8 individual oilers. Maximum practicality in a small central lubrication system. Positive cut-off during idle periods. Individual vibration-proof needle valve adjustments. With solenoid control (illustrated): Style MDS—No. 4685-A. Without solenoid: Style MD.

SIGHT GAUGES

For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

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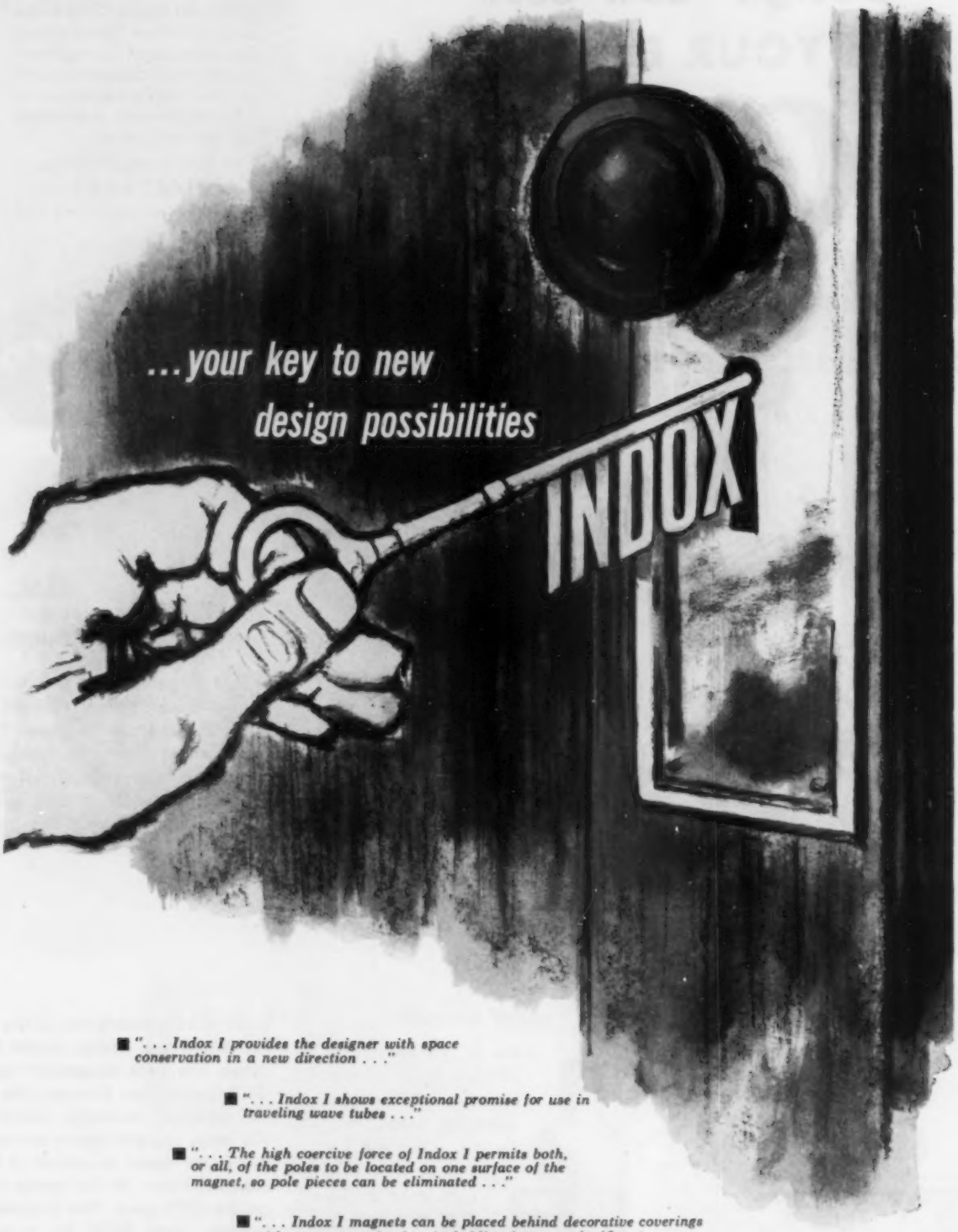

■ *". . . Indox I provides the designer with space conservation in a new direction . . ."*

■ *". . . Indox I shows exceptional promise for use in traveling wave tubes . . ."*

■ *". . . The high coercive force of Indox I permits both, or all, of the poles to be located on one surface of the magnet, so pole pieces can be eliminated . . ."*

■ *". . . Indox I magnets can be placed behind decorative coverings without an excessive loss in holding force—a significant design feature when equipment styling is important . . ."*

■ *". . . The high-temperature coefficient of Indox I opens a completely new field for permanent magnets . . ."*

from "Applied Magnetics"

CERAMIC MAGNETS

If you use permanent magnets, you should investigate the advantages of Indox I . . . the most significant permanent magnet development since the introduction of Alnico!

Indox I opens new and wider horizons of design possibilities. The applications listed below are only some of the more promising.

Smaller size . . . a longer effective life . . . lighter weight . . . savings in cost . . . improved performance . . . are just a few of the benefits already reported by users of this ceramic magnet.

Indox I is *not* a substitute for the magnetically stronger magnets such as Alnico. Instead, it extends the field of application for magnets . . . permitting design changes not always possible with Alnico.

Investigate the advantages Indox I may hold for *your* product. Our design and application engineers will be glad to help. And, because we make *all* types of permanent magnet materials, you can be sure our recommendations will be for that magnet material which will do the best job in your product. For prompt recommendations, without cost or obligation, call or write to Valparaiso today!

These special properties of Indox I:

1. No critical materials
2. High coercive force
3. Magnetization before assembly
4. High resistivity
5. Low specific gravity
6. Cost advantage
7. High potential energy
8. Low incremental permeability

. . . offer significant advantages in these applications:

ELECTRONIC
*TV focuser (1, 2, 5, 6)
Traveling wave tube (2, 3, 5)
*Loud-speakers (1, 2)

HOLDING (1, 3, 6, 7)
*Cabinet latches
*Can openers
*Holding assemblies (flashlights, fishing poles)
Door closers (refrigerators)
Conveyors (automation)
*Toys and novelties

POLARIZING (2, 4, 8)
Sonar
Magnetostriction
cleaning
homogenizing
ultrasonics

ELECTRO-MECHANICAL
*Synchronous drives (1, 2, 6, 7)
Motors
d-c fields (2, 6)
a-c rotors (1, 3, 6, 7)

MISCELLANEOUS
*Arc blowout (2, 4)
*Temperature control

Note: The numbers following each application, or group of applications, identify those properties of Indox I that make it particularly well-suited to that product.
**Indox I magnets are currently being produced for these applications.*

ALNICO
Conventional-type television focuser used three Alnico magnets . . . as shown to right.

INDOX I
Shaded area shows ring type magnet . . . with simpler mounting. There are savings in space and weight.

ALNICO
Note depth of conventionally designed magnet drive unit.

INDOX I
Note *shorter* length of drive unit made of Indox I . . . which also is lighter.

Here's "Applied Magnetics" (Vol. 4, No. 3) which gives you detailed information on the design and application of Indox I Ceramic Permanent Magnets. Use this coupon to ask for your copy:

The Indiana Steel Products Company
Dept. C-10
Valparaiso, Indiana

World's Largest Manufacturer of Permanent Magnets

Please send "Applied Magnetics" (Vol. 4, No. 3).

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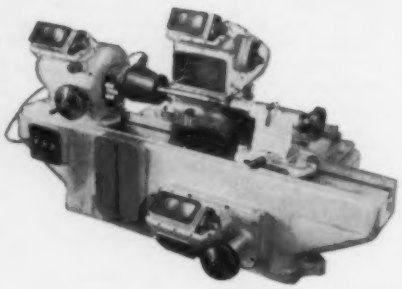
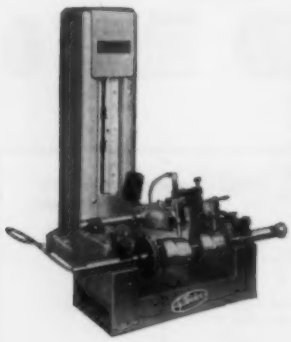
by Parker ... Leaders in 2 and 3 Dimensional Cam Production—and developers of unusual Metalworking contours!

Parker equipment affords ultra-precision in 100% inspection of *Master 3 Dimensional* contours ... The location of a given station can be accurately established to a tolerance of ±.00005", with respect to specified data, by projecting the 3 parameters simultaneously on micrometer verniers. This Universal Optical Measuring Machine is another first in Parker Precision.





With a Parker designed 3 Dimensional Comparitor, an infinite number of stations on production 2 and 3 dimensional cams, can be compared to a master in minutes, where previous methods required many hours. The 3 Dimensional Comparitor gives 100% comparison between ultra-precise *master* and production cams to tolerances of ± .0002".

Send today for "3 Dimensional Cams"—technical data on Parker's ability to make superhuman functions automatic.

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CAM DIVISION
FRANKLIN AVENUE • HARTFORD, CONNECTICUT

fans, crop driers, grain and hay blowers, irrigation pumps, refrigeration compressors and other equipment where continuous duty is required. The motor is manufactured in sizes from 1 to 15 hp. Peerless Electric Co., Warren, Ohio.

For more information—
Circle 68, inside back cover

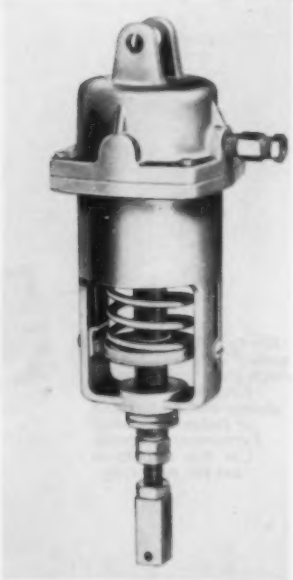
High Resistance Trimming Potentiometer

Subminiature in size, these units can be stacked seven deep in less than 2 sq in. of front panel space. Instrument is screwdriver adjusted over 25 turns, with a self-locking shaft for stable settings. Bourns Laboratories, 6135 Magnolia Ave., Riverside, Calif.

For more information—
Circle 69, inside back cover

Gradual-Acting Motors

Air, water or oil pressure can be used to power three gradual-acting diaphragm motors intended for gradual push-pull control of levers or rods on industrial equipment, as well as for heating, ventilating, and air conditioning control. An infinite number of shaft positions are possible through the stroke range. Available sizes are 3, 4 and 6 in., with respective thrusts of 80, 235 and 500 lb, and maximum



(Continued on page 270)

Bundy Tubing sets new standards for minimum dimensions of return bends

New mass-produced return bends help you solve design problems where space is limited

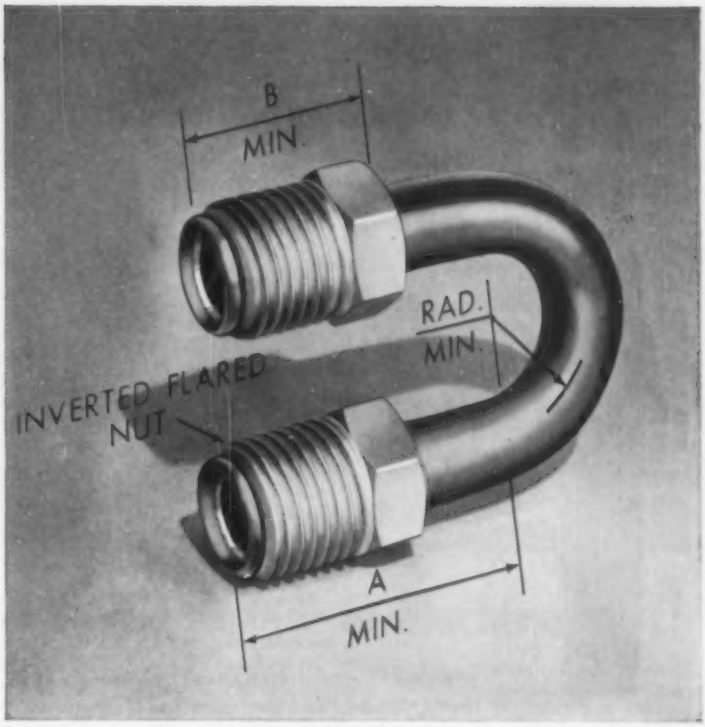
Designers face the unending task of compressing vital equipment into progressively smaller "packages." While helping solve these design problems, Bundy® has established new minimum standards for the mass production of return bends with fittings attached, in tubing from 3/16" to 5/8" O.D.

For example, designing hydraulic actuators for automotive and other uses involves bending tubing to minimum radii, because of severe space limitations. At the request of leading fabricators, Bundy developed the minimum mass-production standards tabulated at right. For special problems, where space is more important than speed of production, Bundyweld® can be fabricated to even closer tolerances.

Bundyweld Tubing takes such fabrication easily because it's the only tubing double-walled from a single metal strip, copper-bonded through 360° of wall contact. The result: stronger, vibration-resistant tubing with high bursting strength and high thermal conductivity. No wonder Bundyweld is the accepted standard of the refrigeration and automotive industries: *it is used in 95% of today's cars, in an average of 20 applications each.*

Add to this, expert, free engineering service, and you know why Bundyweld Tubing solves even the most difficult tubing problems. Call, write, or wire us today!

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN



TUBE O.D.	3/16	1/4	5/16	3/8	7/16	1/2	5/8
RAD.-MIN.	3/16	3/8	5/8	3/4	7/8	1	1 1/2
A-MIN.	3/4	7/8	1	1 1/16	1 1/8	1 1/4	1 3/8
B-MIN.	5/8	5/8	11/16	23/32	3/4	13/16	7/8
Bundy Part No. of S.A.E. St'd Inverted Flared Nut	P-2208	P-2205	P-2206	P-2207	P-2266	P-2267	P-2359

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, GERMANY, AND ITALY

Bundyweld starts as a single strip of copper-coated steel. Then it's . . . continuously rolled twice around laterally into a tube of uniform thickness and passed through a furnace. Copper coating fuses with steel. Result . . . Bundyweld, double-walled and brazed through 360° of wall contact.

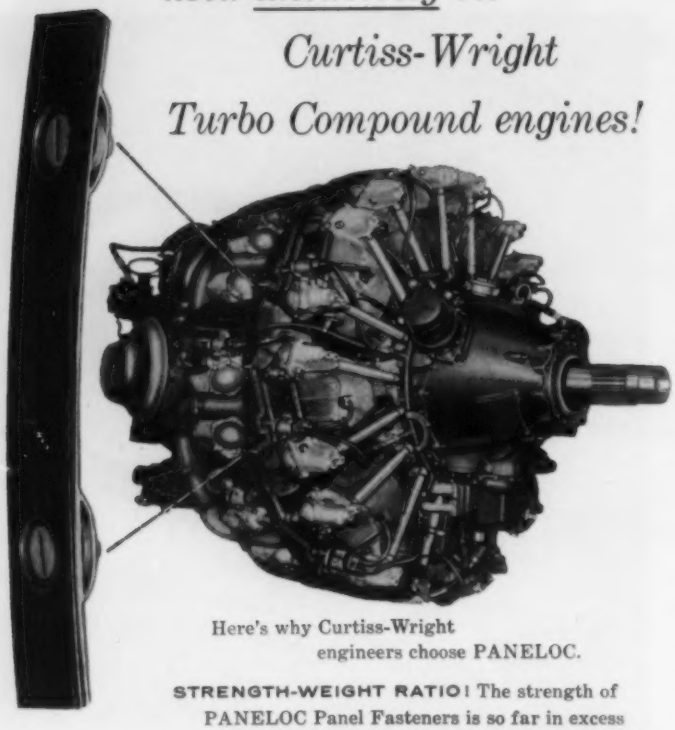
NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

BUNDYWELD® TUBING

DOUBLE-WALLED FROM A SINGLE STRIP

PANELOC

panel fasteners
used exclusively on
Curtiss-Wright
Turbo Compound engines!



Here's why Curtiss-Wright engineers choose PANELOC.

STRENGTH-WEIGHT RATIO! The strength of PANELOC Panel Fasteners is so far in excess of requirements of governing specifications that fewer fasteners are required to do a particular job. This saves the weight of extra fasteners.

LONG LIFE! PANELOC Panel Fasteners are still operative when baffles and ducts wear out. Maintenance is thereby reduced to a minimum. The need for replacements is virtually eliminated.

ECONOMY! The cost of extra fasteners is eliminated and the cost of installation and maintenance reduced when PANELOC Panel Fasteners are used.

PANELOC

Write for catalogues and price lists on Styles 1, 2 and 3 Panel Fasteners.

A product of SCOVILL

Scovill Manufacturing Company, Aircraft Fastener Div.
49 Mill Street, Waterbury 20, Connecticut

strokes 2¼, 3, and 4⅛ in.

In operation, air or hydraulic pressure on the molded neoprene diaphragm advances the spring-loaded piston. When pressure is relieved, the spring returns the piston to its starting position. Length of the piston's forward and return strokes, as well as the pressure required to start the motor, are adjustable on all three motor sizes. Powers Regulator Co., 3434 Oakton St., Skokie, Ill.

For more information—
Circle 70, inside back cover

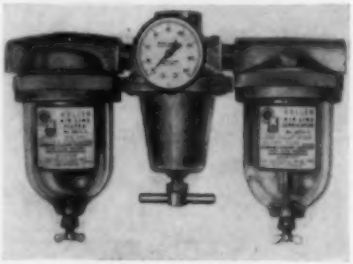
Low Level Digital Ohmmeter

This instrument displays five digits, and accuracy is within 0.01 per cent, ±1 digit, from 0.01 ohm to 100,000 ohm, with ranges to 10 megohms at reduced accuracy. Range is indicated by a lighted, automatically-positioned decimal point. Overall panel size of the unit is 7 x 19 in. It is designed to be mounted in standard racks. Electro Instruments, Inc., San Diego, Calif.

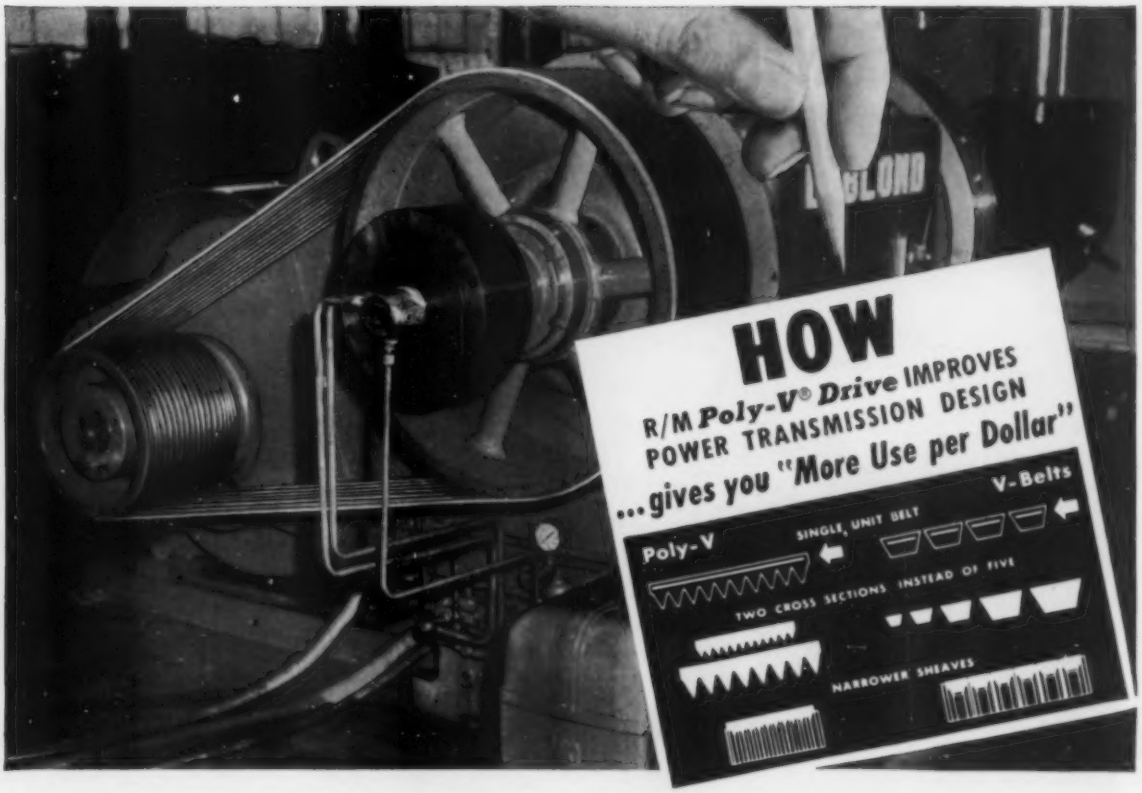
For more information—
Circle 71, inside back cover

Filter-Regulator-Lubricator

This air line filter-regulator-lubricator drains from the bottom without removing the bowl. The pressure regulator operates in an inverted posi-



(Continued on page 274)



This *Poly-V® Drive* Saved $2,000 in Machine Cost!

No other belt drive delivers as *much power* in as *little space* as R/M Poly-V Drive. Designers of the giant boring lathe pictured above took advantage of this exclusive Poly-V feature—specified a single unit Poly-V Drive to replace the 13 multiple V-belts previously used on the lathe drive. Results? Sheave width was reduced 30%, eliminating the need for a cumbersome outboard bearing to handle excessive drive weight. . . . This *saved $2000 in the cost of the machine.*

It's another example of why design engineers are calling the patented R/M Poly-V Drive the ideal drive for heavy duty power transmission. Poly-V employs a single, endless V-ribbed belt running on sheaves designed to mate precisely with the belt ribs. You get up to 50% more power in the *same* space as a multiple V-belt drive, or *equal* power in as little as 2/3 the space —with *less* shaft overhang, less drive weight!

Space and weight saving features are just part of the story. There are no belt "matching" problems with Poly-V Drive and just *two* belt cross sections meet every heavy-duty power transmission requirement! Poly-V Drive maintains constant pitch diameter at all loads. Belt speed ratio and belt position are maintained from no load to full load to assure a smoother, cooler running drive . . . reduce belt and sheave wear.

Advantages of this amazing new drive concept add up to improved machine design and real economy—"More Use per Dollar"—for both new and existing equipment. Let R/M engineers work with you on your power transmission problems. Contact an R/M representative . . . or write for Poly-V* Drive Bulletin #6638.

CONDOR V-BELTS • R/M SUPER-POWER V-BELTS

Write for Bulletin #6868 on the complete line of Condor V-Belts for regular service on conventional V-belt drives. Also write for Bulletin #6628 on R/M Super-Power V-Belts with 40% more Horsepower capacity where needed.

*Poly-V is a registered Raybestos-Manhattan Trademark RM-620

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.

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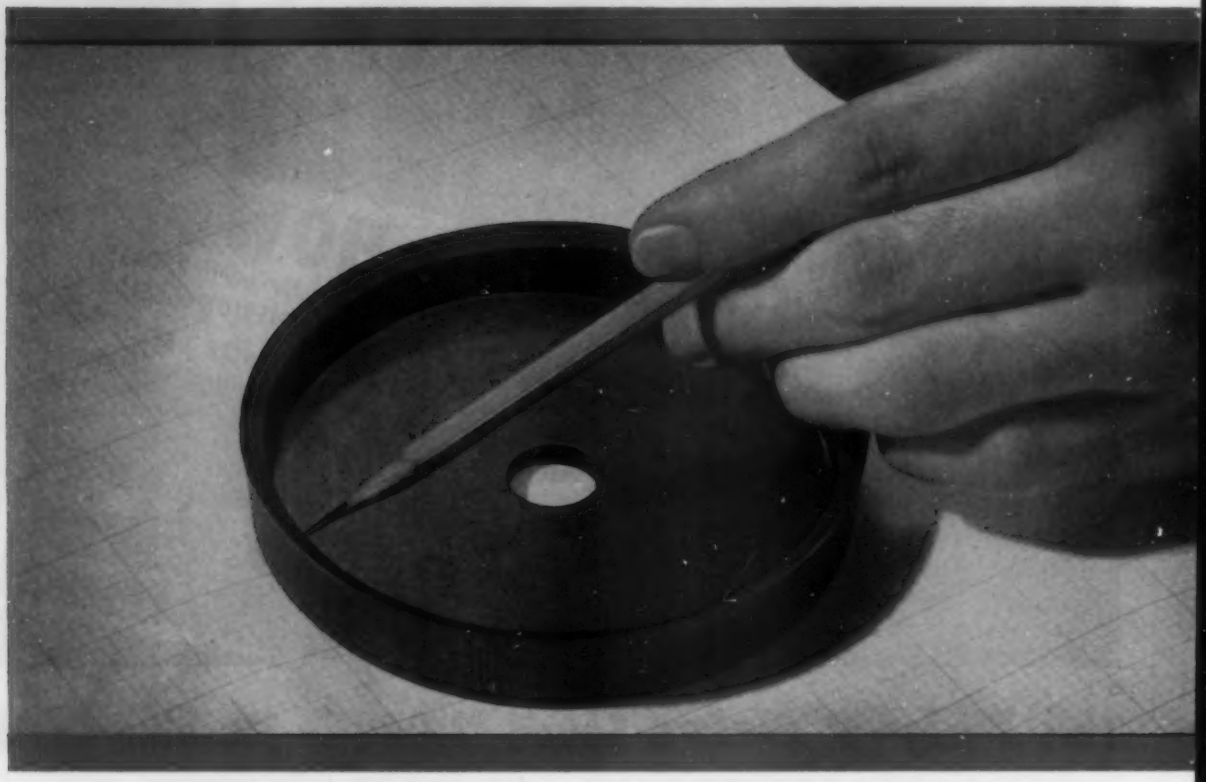

A CLEAR CASE OF QUALITY . . . R/M FABRIC PISTON CUPS

Designers of hydraulic and pneumatic equipment like these quality features built into R/M Fabric Piston Cups because they mean extra performance and longer wear:

1. Precision molding—Note the clear definition of contours, smooth surfaces, clean trimming—all evidence of top-flight molding practice.

2. Superior impregnation—Cut an R/M Fabric Piston Cup and you will see how R/M's special method gives deeper, more thorough penetration of the compound into the fabric. This keeps wicking action from destroying the cup internally and gives greater resistance to ply delamination.

3. Controlled tolerances—Careful quality control insures dimensional uniformity, consistent hardness, and strict adherence to industry standard sizes.

R/M Fabric Piston Cups are available to fit cylinders from ½ to 12 in. in diameter. Types are furnished in varying degrees of hardness for pressures up to 1500 psi and in different compounds to meet specific operating conditions.

For booklet shown, or other data, write, phone or wire:

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R/M

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Fan Belts and Radiator Hose

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Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS

FRICTION MATERIALS

Unlike other manufacturers, R/M works with *all* kinds of friction materials, from asbestos to sintered metals. This means that when you consult an R/M engineer you can be sure of completely unbiased advice on which materials are best for your application.

Raybestos-Manhattan has been the world's largest maker of friction materials for over 50 years. Whatever your brake or clutch requirements, count on R/M experience, and R/M manufacturing and testing facilities, for a friction material exactly suited to your needs.

Write for your copy of R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

EQUIPMENT SALES DIVISION
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R/M SUPER-POWER V-BELTS

On heavy duty drive designs you can increase drive capacity as much as 40% with R/M Super-Power V-belts . . . *without* changing present drive design! Or you can save space in *new* drive designs by using narrower sheaves and fewer belts to meet horsepower specifications. New stretchless, super-strength synthetic cords give R/M Super-Power V-belts the extra power capacity. Straight sidewalls give them better tensioning and grip . . less slip and longer life on the most rugged drives. All-synthetic rubber construction makes them oilproof, non-spark and heat resistant. You'll find the same engineering in Condor V-belts for general drive applications. Whether your application calls for V-belts, rubber hose, conveyor belts, flat transmission belting or precision molded or extruded parts . . . let R/M specialists work with you on your design problems.

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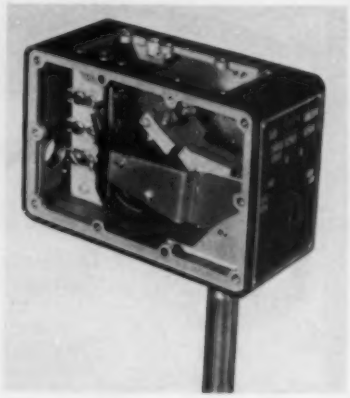
tion. The unit is available in any combination or as individual units for $\frac{3}{8}$, $\frac{1}{2}$ or $\frac{3}{4}$ in. compressed air line. Keller Tool Div., Gardner-Denver Co., Grand Haven, Mich.

For more information—
Circle 72, inside back cover



Temperature Controller

Operation is by the difference in expansion of two concentric tubes when exposed to heat. The resulting movement is multiplied through a lever arrangement which actuates one or more switches. Temperatures from zero to 2000 F can be handled and standard switch rating is 15 amp. 125-250 v, a-c, but higher ratings are available. Burling Instrument Co., 16 River Road, Chatham, N. J.

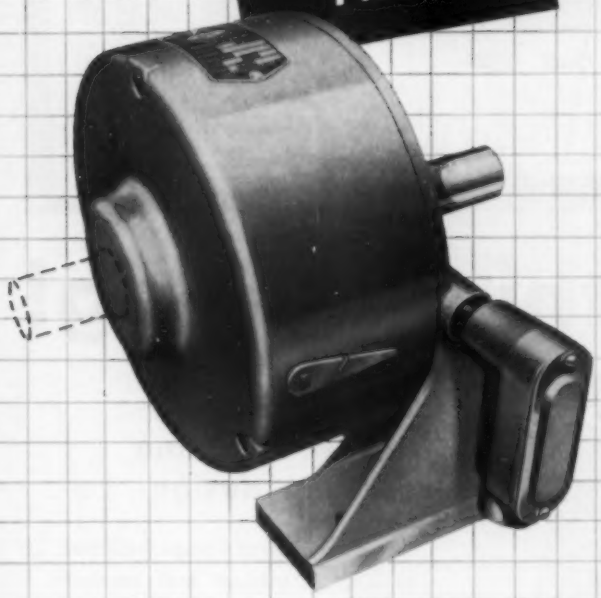
For more information—
Circle 73, inside back cover

Concentric Scale Dial

A line of direct reading concentric scale dials has a fingertip brake which prevents accidental change of setting.

(Continued on page 279)

Another REULAND First!



NEW *REULAND* FOOT-MOUNTED MAGNETIC BRAKE (DISC TYPE) ...COMPLETE with SHAFT and BEARINGS

First and Only Disc-Type Brake to fulfill J. I. C. Specifications The efficient, direct-action operating advantages of the Reuland disc type magnetic brake are now available for the first time in this self-contained unit. Being foot-mounted, it can easily be coupled to existing motor or equipment shafts in accordance with J.I.C. specifications. As a standard unit it also can be purchased "off the shelf" by O.E.M.'s or added to equipment at any time by users. Available with either single or double end shaft.

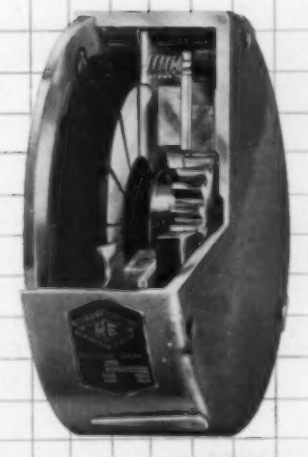
Also available without shaft Reuland disc type magnetic brakes are also supplied for applications where the motor or equipment shaft can be extended directly into the brake. These units are available in both foot-mounted and endbell mounting types. Together with the completely self-contained unit described above, these brakes provide low cost, compact size and efficient operating features that are unequaled.

Reuland Brakes provide great versatility

Shaft can be extended entirely through brake, when desired. Also, hook-ups with Reuland Fluid-Shaft motors and Motoreducers permit many J.I.C. and other unique power and braking combinations...combinations that can be tailored to your exact drive requirements without huge, special development costs.

Check these added features

- Automatic lining wear adjustment
- Manual release with automatic reset
- Direct action — no levers or linkage
- One-piece, totally enclosed housing
- One-half usual length — pleasing lines



Cutaway view of endbell mounting type

Other Reuland Firsts

1. Motor with internal fluid coupling
2. Spline coupled hydraulic pump motor
3. All-aluminum motor frames
4. "Xpandable" motor design
5. Slip Ring Motors in small #66 frames
6. "Through-Shaft" magnetic disc brakes
7. Precision motors for machine tools

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Don't ever pay for special-motor development costs before you check this free library. Contains valuable data on hundreds of unique specially designed motors. Send for free "how to use" booklet.

Standard Motor Catalog

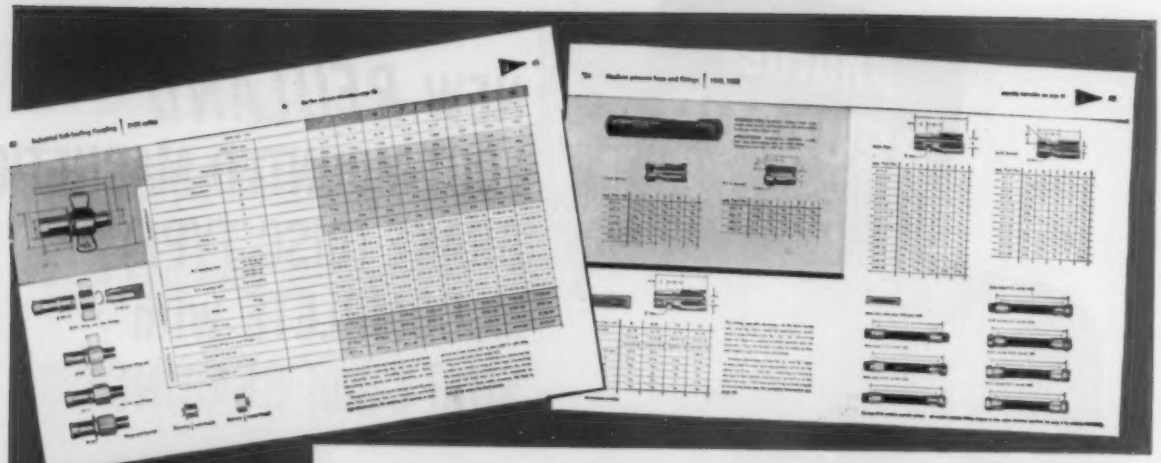
Contains engineering information on Reuland's complete line of standard motors and motoreducers. Sent free on request.

REULAND MOTORS

REULAND ELECTRIC COMPANY

Western Division: Alhambra 54, California
Eastern Division: Howell 54, Michigan

Distributors in all principal cities



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You'll find 18 pages of valuable fluid line data to help you in the planning, engineering and installation of fluid line systems on all kinds of industrial equipment.

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Lithoform Z forms an amorphous chromate coating on zinc and cadmium surfaces which retards the formation of *white rust* or *bloom*. It is effective on most types of electro-deposited zinc, zinc die casting alloys, hot-dipped galvanized surfaces, and cadmium plated products.

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Write for complete information about these ACP corrosion preventives

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CHEMICALS ACP PROCESSES

Dial is 1¾ in. dia. The turn-counting dial reads up to 10 turns. Increment dial has 100 equal divisions and is attached directly to the actuating shaft, eliminating backlash. This indicates position to an indexed accuracy of one part in 1000. Operation is continuous in either direction. George W. Borg Corp., Janesville, Wis.

For more information—
Circle 74, inside back cover

Oil-Fog Lubricator

This 6 x 6 x 5¼ in. unit supplies air-actuated feed mechanisms, chucks, clutches, brakes and other air-operated parts if machine tools with filtered air, regulated air pressure and lubrication. Oil particles are of micron size. Performance over an air flow range of 4 to 85 cfm is provided.

Designed for main line air pressures not exceeding 150 psi and for regulated air pressures of less than 125 psi. Available in ¼ in. pipe size. C. A. Norgren Co., 3400 S. Elati St., Englewood, Colo.

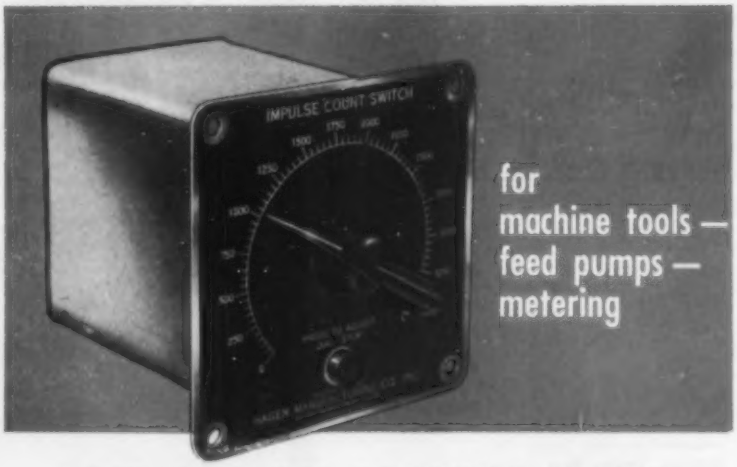
For more information—
Circle 75, inside back cover

Air Pressure Hydraulic Valve

A hydraulic four-way valve is air pressure-operated by air pilot valve. It is available in standard action, spring-return, and spring-centered: with spring-return valve, the piston is moved to original position when pilot pressure is drained off. It requires one air pilot line for remote operation in one direction. Spring-centered valves require air pilot lines to each end of valve for remote operation in either direction, and when both pilot

(Continued on page 282)

HAGEN count switch



for machine tools — feed pumps — metering

PAID FOR BY SAVINGS MADE ON JUST 1 TOOL

Simply set this Hagen Count Switch to the number of operations at which a tool should be changed. The count switch trips a switch after a preset number of electrical impulses . . . and thereby shuts down the machine automatically. Tool wear never reaches the point where tools must be ground down excessively to resharpen. That means increased tool life, reduced tooling costs and fewer rejects. Compare the savings on just *one* tool with the cost of this reasonably priced Hagen Count Switch. Chances are, the savings will be much greater.

This Hagen Model 70 Count Switch has 72 dial divisions . . . 72 possible settings. Dials are available with up to 54,000 counts. Accuracy: 1% of full scale range. Ideal for feed pumps and metering operations. Send coupon for Bulletin 780 — or data on the complete line of reset and repeating cycle timers and counters, interrupters and control assemblies.

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Dept. PE-1056, Moline, Illinois

☐ Please send free Bulletin 780 on Hagen Count Switch.
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NAME AND TITLE
COMPANY
ADDRESS
CITY ZONE STATE

McFarland Fire Wagons, distributed by the Unox Co., Houston, Texas. Hose basket is formed from Penmetal expanded metal.

How expanded metal helps fight fires

Feature of the McFarland line of Wetter Water Fire Wagons is a basket mounted at the front of each unit – keeps the hose in a handy, compact coil.

The design of these hose baskets is interesting because it represents a neat solution to a construction problem. They had to be *strong* enough to take the weight and use-abuse of many feet of high pressure hose . . . *light* enough to keep within portability requirements. Other factors were appearance and cost.

McFarland Manufacturing Co. found the perfect answer to all their requirements in Penmetal expanded metal. This versatile material is sheet metal slit and expanded to as much as ten times original width. 80% lighter than solid sheet, the diamond truss pattern adds rigidity and strength. It's easily formed, shaped and welded . . . and, is low in cost.

The wide range of valuable properties available in expanded metal has made it the ideal material for many, many jobs. Examples: Fan enclosure; portable heater guard; parts basket for industrial cleaner; T.V. base; radar antenna.

Want to turn your problem into a profit? Send for further details – today. Ask for a copy of Catalog No. 509-EM.

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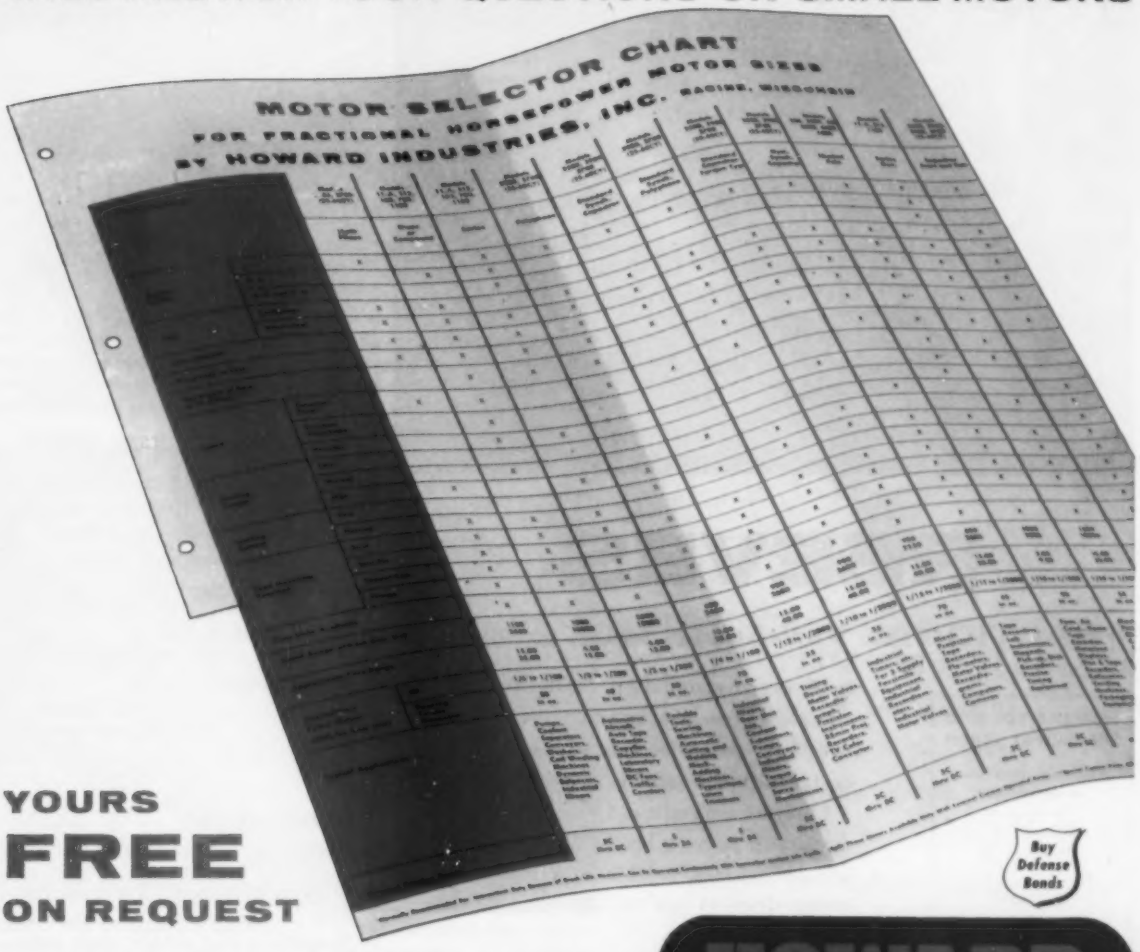
WILL ANSWER YOUR QUESTIONS ON SMALL MOTORS



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Characteristics and performance ranges of all fractional h.p. motor types are charted in detail in this new binder sized Fractional H.P. Motor Selector Chart now available to Engineers and Purchasing Agents. Speed-torque curves for basic motor types are illustrated as well as other valuable motor data. Compiled by the Howard engineering department, the Howard Motor Selector is yours for the asking. Just fill in the coupon below for your free copy by return mail.

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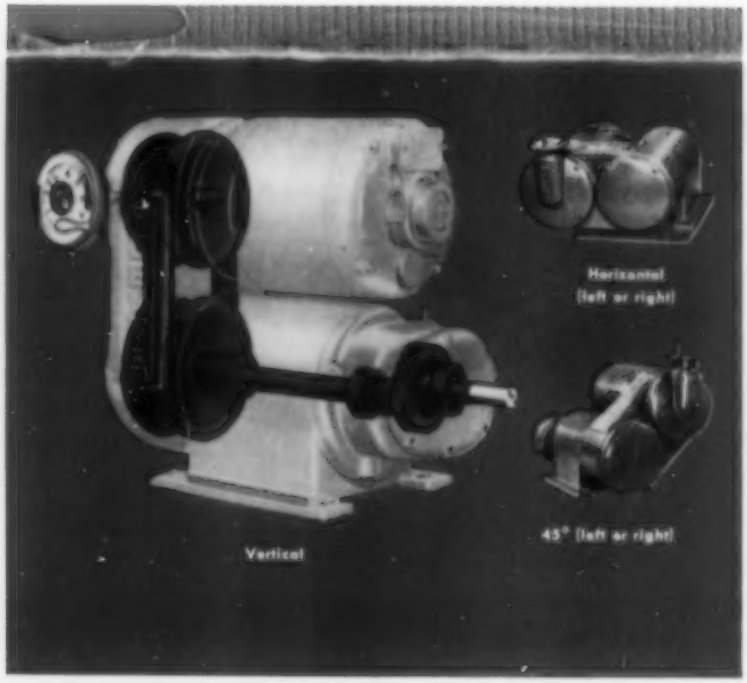
Variable Speed – Styled For Compact Machine Designs

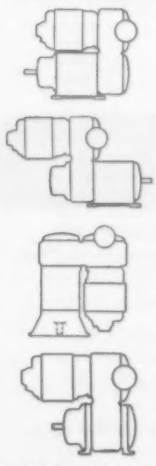


REEVES

FRACTIONAL *Vari-Speed* MOTODRIVE

WHERE DO YOU NEED THE OUTPUT SHAFT?

Motor side, control side, or vertical down



▶ REEVES fractional hp. Motodrive is a complete power package, engineered in over 100 assemblies to fit wherever your design calls for variable speed.

Choose from vertical, 45° or horizontal models in ¼ to 1 hp. . . . get stepless accurate speeds—within a 2:1 to 10:1 range—from as low as 3 rpm to a maximum of 4660 rpm.

Available in standard, weather resistant, totally enclosed or splash-proof enclosures; full range of manual or automatic controls.

REEVES Motodrive—the *right* speed for *every* need . . . in *any* place.

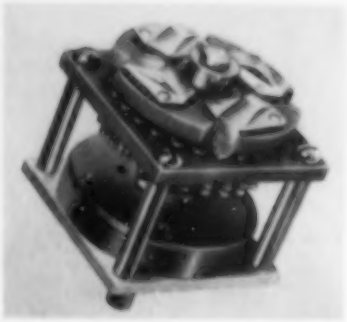
Write Dept. K23b-M543 for ratings and dimensions.

REEVES PULLEY COMPANY
Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.
Columbus, Indiana

pressures are drained off, the piston is spring-centered.

These valves are offered in seven sizes, ¼, ⅜, ½, ¾, 1, 1¼ and 1½ in. Spring-centered valves are available in five piston designs to meet the requirements of any hydraulic circuit; standard action and spring-return action valves are available in one piston design. Rivett, Inc., Brighton 35, Boston, Mass.

For more information—
Circle 76, inside back cover



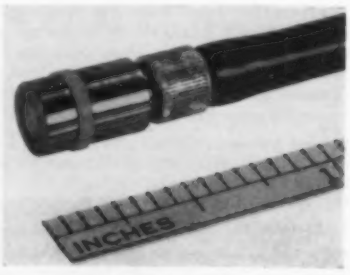
Knee-Action Rotary Switch

This switch is 1¾ in. square and is available with as many as four poles on a single deck. In addition, as many as seven positions per pole, with shorting action, and four positions per pole, with non-shorting action, can be obtained with the new units. Daven Co., 530 W. Mt. Pleasant Ave., Livingston, N. J.

For more information—
Circle 77, inside back cover

Miniature Pressure Transducers

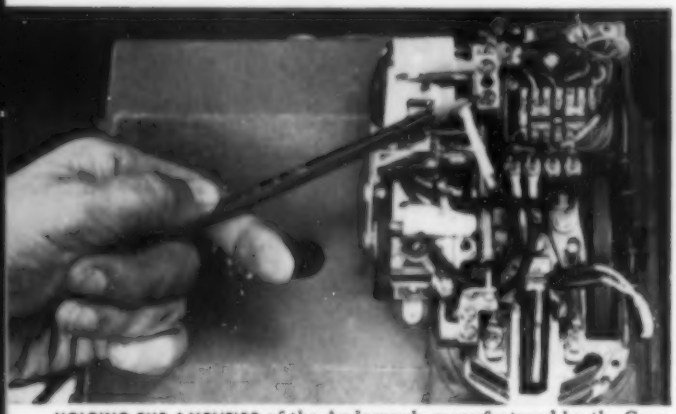
These transducers, ¼ x ½ in. long, have a response time of 1 microsec. Available in four models, these instru-



(Continued on page 284)

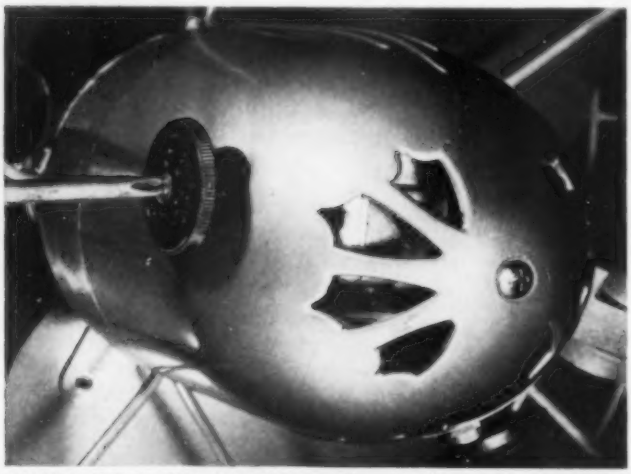
PHILLIPS CROSS RECESSED HEAD SCREWS

are holding down many important jobs



HOLDING THE AMPLIFIER of the Audograph, manufactured by the Gray Manufacturing Company, there are Phillips screws. Mr. William Sherman, Director of Sales, says, "Phillips screws enable us to meet the rugged performance standards required of the Audograph machine and to meet our competition in the dictation field."

HOLDING THE pro-SURE-tool of the Buchanan Electrical Products Corporation, are four Phillips screws. "By switching to Phillips screws we accelerated production, prevented driver slippage, increased the torque applied to each screw and eliminated the unattractive 'chewed up' screw head," says Mr. Mittleman, Plant Superintendent and Production Manager.



HOLDING THE OSCILLATOR KNOB as well as the fan head cover of the Fasco Industries, Inc., fans, you'll find Phillips screws. Mr. Weiland, Assistant Purchasing Agent of the company says, "When we introduced Phillips screws, we immediately improved assembly. They also eliminated burring and improved the appearance of Fasco fans."

MANUFACTURERS OF PHILLIPS CROSS-RECESSED-HEAD SCREWS

THE FASTENERS OF TODAY...
AND OF THE FUTURE
X marks the spot
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The Phillips Screw manufacturers listed here cooperate to turn out a uniformly high standard of quality. As sponsors of the Phillips Cross-Recessed-Head Standards Committee they adhere to the established dimensional standards, gauges, and gauging methods which will best serve industry.

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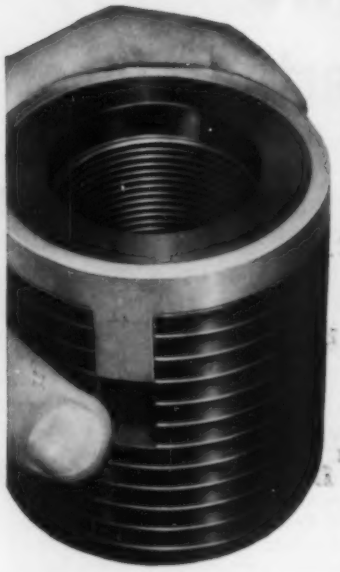
smaller . . . lighter assemblies



KELOX tapped and threaded inserts provide new opportunities for reducing the size and weight of assemblies. Patented "key-locking" produces no stress concentrations and allows complete use of external threads for maximum holding power. KELOX design affords minimum depth of insert. The ability of KELOX inserts to withstand high torques has been verified without reservation by an independent laboratory.

Available for all external thread sizes from 0 to 3 inches, low-cost KELOX inserts are easy to install and remove . . . made of many materials (alloy steel, corrosion-resistant steel, aluminum alloy, brass, monel, etc.) . . . come with thick or thin walls for use with most materials—aluminum, magnesium, plastic, "pot" metal, titanium, steel, etc.

EXTRA LARGE

The ever-increasing use of extra-large KELOX inserts (up to any specified diameter) is a result of their unmatched performance—a performance that verifies the "key-locking" principle. KELOX inserts will not rotate or loosen with vibration . . . make optimum use of tapped hole . . . provide maximum holding power . . . save weight and space.

EXTRA SMALL

Sub-miniature inserts in 0, 1, 2, 3, and 4 thread sizes, *made only by KELOX*, will make miniature assemblies even smaller and lighter. Identical to regular non-rotating KELOX inserts . . . do not break down protective coatings like ceramic . . . require no special threads . . . give maximum reduction of space and weight for improved product design.

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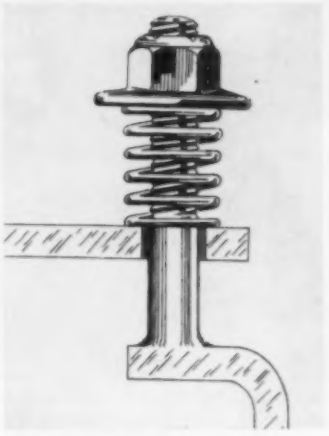
Culver City, California

ments cover a range of pressures from 0.01 to 100,000 psi. Kistler Instrument Co., 15 Webster St., N. Tonawanda, N. Y.

For more information—
Circle 78, inside back cover



Flanged Base Self-Locking Nut

A nut designed with a large washer-type seat can be used to provide spring tension adjustment. The nut is made from steel with a plain or plated finish. Elastic Stop Nut Corp. of America, Union, N. J.

For more information—
Circle 79, inside back cover

Rotary Solenoid Valve

Developed for high pressure aircraft hydraulic, pneumatic and fuel systems over a pressure range of zero to 3,000 psi, this valve handles most fluids, including liquid oxygen and ni-

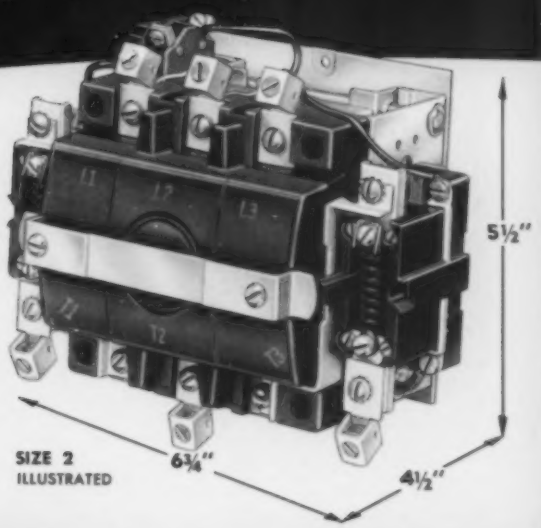
(Continued on page 287)

BY FAR THE *Finest* EVER BUILT

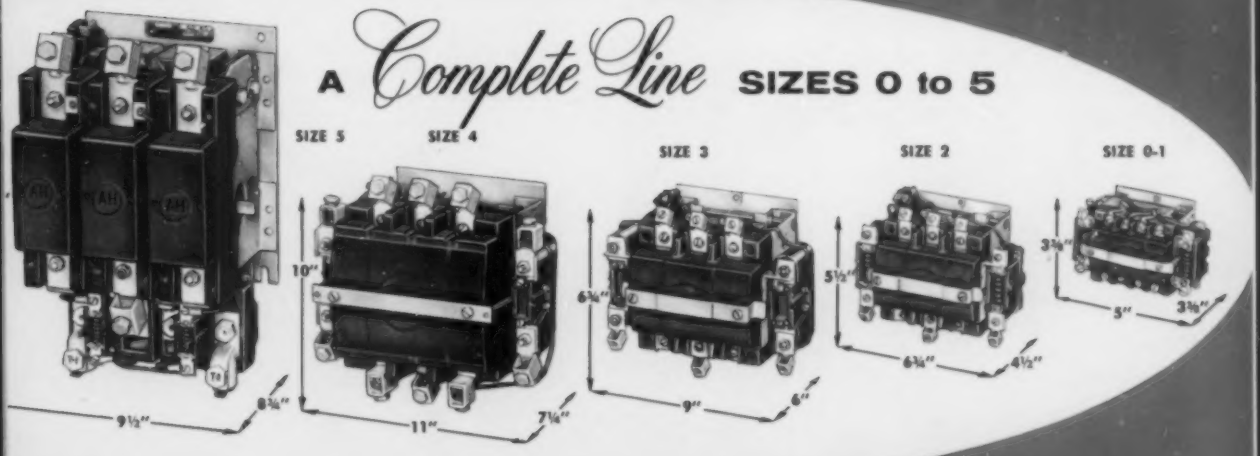
and HALF THE SIZE of Conventional Types

ARROW AH HART

MAGNETIC MOTOR CONTROLS



A *Complete Line* SIZES 0 to 5



When SMALL Space is a BIG Design Problem! . . .

Complex, modern machines call for multiple motor controls; fitting this control equipment into a reasonable area and providing ready accessibility is often a serious design problem. You can solve it easily by specifying Arrow-Hart Type "RA" Motor Controls. Radically smaller and lighter than conventional types, these starters and contactors offer the additional benefits of matchless performance, far greater dependability and much longer life.

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ARROW AH HART

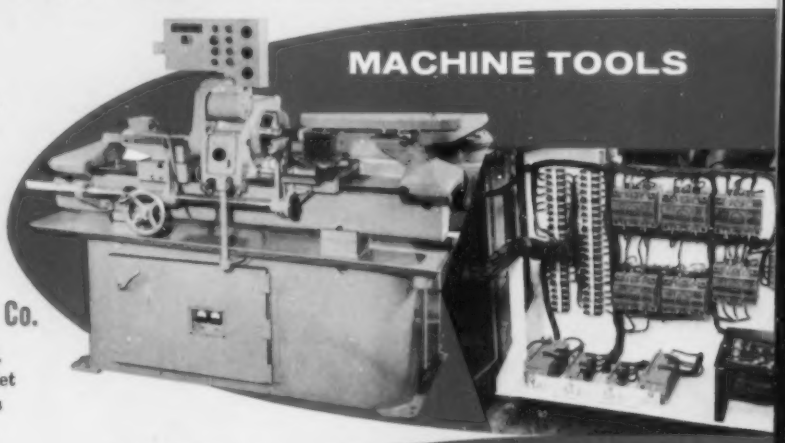
THE ARROW-HART & HEGEMAN ELECTRIC CO., Hartford 6, Connecticut

The Leaders look to ARROW AH HART *Advance Design*

MOTOR CONTROLS

. . . FOR SPACE-SAVING COMPACTNESS

. . . FOR PERFORMANCE-BUILDING DEPENDABILITY

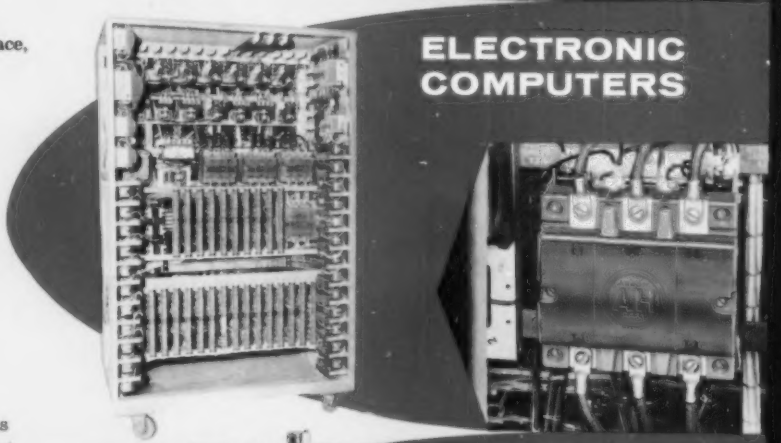


MODEL 102 AIRFOIL MILLING MACHINE

MANUFACTURED BY

The New England Machine & Tool Co.

This ingenious machine mills the original, 3-dimensional masters from which turbo jet blades are manufactured . . . does in hours a job once requiring weeks of hand work. Complexity of the operating and control mechanisms placed a high premium on space, but the 5 smaller, lighter A-H Magnetic Controls were easily mounted on an unusually compact door-back panel that swings out for instant accessibility.



TYPE 704 ELECTRONIC DATA PROCESSING MACHINE

MANUFACTURED BY

International Business Machines CORPORATION

These electronic machines are designed primarily for the use of engineers and research scientists. They are capable of performing more than 4000 multiplications or divisions per second. The 10 Arrow-Hart Contactors included in the very complicated power distribution unit were a natural choice to save valuable space. Other A-H Controls are also utilized in other parts of the machine.

HEV-E-OIL BURNER

MANUFACTURED BY

Cleaver-Brooks Company

Simple, compact and efficient, this modern unit uses low cost, high heat heavy oils to provide economical heat for commercial and industrial buildings. Arrow-Hart Control – an "RA" Starter and a Miniature Relay – occupies little space in the small panel, leaves ample space for easy wiring.

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 Hawthorn Street, Hartford 6, Connecticut
MOTOR CONTROL DIVISION

Please send my copy of the A-H Motor Control Application folder. PE

name _____
position _____
company _____
co. address _____
city _____ zone _____ state _____

ARROW AH HART

ARROW-HART

MOTOR CONTROL DIVISION
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY
103 HAWTHORN STREET, HARTFORD 6, CONNECTICUT

Offices, Sales Engineers and Warehouses in Principal Cities

Quality MOTOR CONTROLS • WIRING DEVICES
ENCLOSED SWITCHES • APPLIANCE SWITCHES

MAIL COUPON TODAY FOR COMPLETE INFORMATION

trogen. The small, light-weight valve features straight-through flow and is available with ports for ¼, ⅜ or ½ in. dia tubing. Models are available either normally open or normally closed. Pneu-Hydro Valve Corp., 364 Glenwood Ave., East Orange, N. J.

For more information—
Circle 80, inside back cover

Direct-Mounting Potentiometer for Printed Circuits

Because it mounts directly on the board by its own round leads, this potentiometer eliminates the use of screws and lugs. Measuring ½ x ¼ in. high, terminal linearity is ±3 per cent. Resistance range is 10 to 35,000 ohm; dissipation, 2 w. George-Held, Inc., 1020 N. La Brea, Los Angeles 38, Calif.

For more information—
Circle 81, inside back cover

Powdered Iron Clutch and Brakes

The clutch has a rating of 80 in-oz of torque at approximately 5000 rpm, and an output inertia of 1.85 sq cm. The speed of response is on the order of 2 millisec.

Inasmuch as the excitation coil is fixed, slip rings and external bearings are not required. This unit has only two moving parts.

The brake is a high speed, reversible device that will deliver 80 in-oz of torque for either on-off service and/or for a proportional drag. The ratings are the same for either direction of

(Continued on page 290)

Perkins Precision Gears

Custom-Made for SIKORSKY

...made by PERKINS to SIKORSKY'S specifications for exacting, heavy duty service

Before YOU order GEARS, *Check Perkins!*

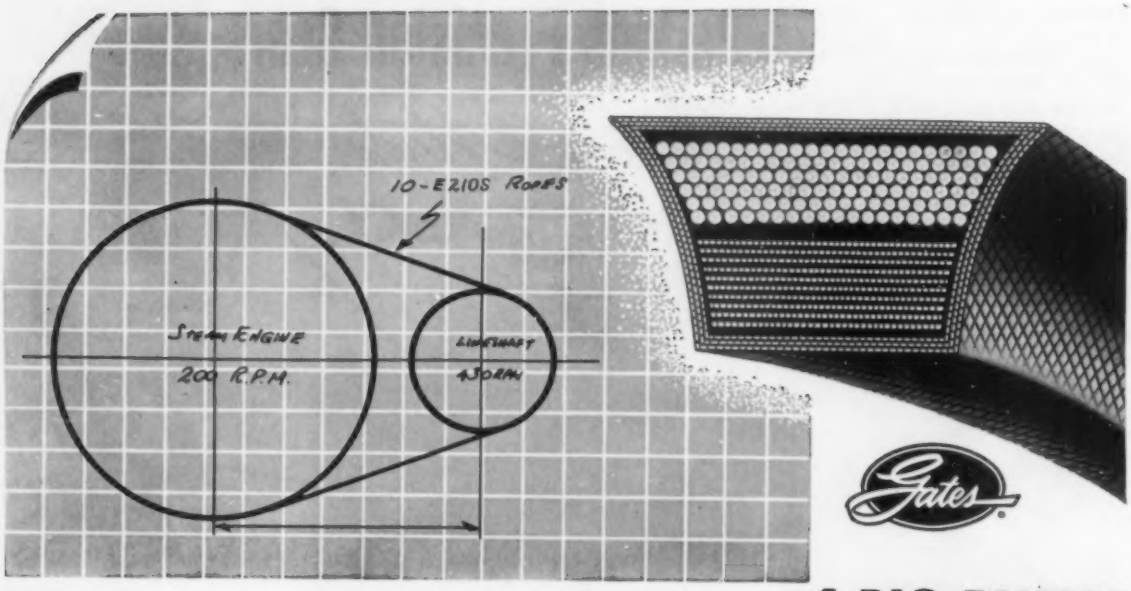
PERKINS MAKES:

to customers' specifications, in all materials, metallic and non-metallic: bevel gears, ratchets, sprockets, ground thread worms, spiral gears, helical gears, spur gears with shaved or ground teeth.

NOTE: The PERKINS PRECISION SPRING COILER is the latest development in the spring coiler field and eliminates entirely the use of arbors and long set-up time. It is a complete self-sufficient machine and enables you to make the spring you want when you want it—in seconds. The coiler produces any type of spring, in any diameter and any pitch with this range: Wire sizes .005 to .125. Diameter, from 3/32" to 12" and larger. Size of the compact coiler is only 7½" x 16". A POWER MODEL is available. Information on request.

PERKINS MACHINE & GEAR CO.

105 Circuit Ave. West Springfield, Mass.



MORE HP DELIVERED PER $ INVESTED

On any new drive design—where you have limited space or you need to keep weight down—here is an important fact that can save you money:

A Gates Super Vulco Rope drive will deliver more horsepower per dollar invested than any standard V-belt drive.

Actually, the greater load carrying capacity of Super Vulco Ropes cuts down the number of belts required (5 Super Ropes do the work of 7 standard belts) . . . thus reducing the width of sheaves.

Sheaves with fewer grooves not only cost less, they weigh less, and take up less room—advantages that can easily improve the design and lower the overall cost.

A wealth of drive data is quickly available to you. Simply call your nearby Gates V-Belt Distributor (see 'phone book yellow pages) for a Gates V-Belt Specialist. Stocks available in industrial centers around the world. The Gates Rubber Co., Denver, Colorado—*World's Largest Maker of V-Belts.*

4 BIG PLUSES

✚ *Handles shock loads*

Super-strength cords provide 40% greater horsepower capacity . . . easily absorb heavy shock loads.

✚ *Wears far longer*

Concave Sidewalls (Fig. 1) increase belt life. As belt bends, concave sidewalls (U.S. Pat. No. 1813698) become straight, make uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . longer V-belt life.

Flex-Weave cover (U. S. Pat. No. 2519590) provides greater flexibility with far less stress on fabric. Cover wears longer—increases belt life.

✚ *Provides Static Safety*

High electrical conductivity is built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

✚ *Resists oil, heat and weather*

Special rubber compounds with which cords and fabric are impregnated make Super Vulco Ropes highly resistant to heat, oil and prolonged exposure.

TPA 76

Gates Super VULCO ROPE Drives

LUBRICATION A PROBLEM?
*why not try *PUREBON . . .*

* CARBON-GRAPHITE ESPECIALLY DESIGNED FOR MECHANICAL APPLICATIONS

PROPERTIES OF PUREBON

1. **Molded to size—for many applications.**
2. **Readily machineable to any intricate shape.**
3. **Chemically inert—non-toxic, resists attack by most chemicals.**
4. **Dimensionally stable — does not warp or distort at high temperatures.**
5. **Light weight — low cost where molded to size.**
6. **Low coefficient expansion — good electrical conductivity.**

Purebon is the ideal solution to many knotty problems facing designers today involving sliding or rotating parts where lubrication is difficult or impossible. Many grades of Purebon can be run dry at temperatures as high as 1000°F. Water, acids, gasoline and jet fuels make ideal lubricants for many grades of Purebon. *(Whatever your problem, there is a grade of Purebon for its solution.)*

For complete information about Purebon, write for new Bulletin No. 55.

PURE CARBON CO., INC.
448 HALL AVENUE **ST. MARYS, PA**

NOW ...The Aerosol Lubricator

MACHINE TOOL DESIGNERS

Have been asking for

Norgren

MICRO-FOG® 33AG-4

COMPACT
This new unit measures 6-1/32" x 5-3/16" x 6-1/32".

COMPLETE
Includes an Air Line Filter, a relieving type Air Pressure Regulator, and a MICRO-FOG Lubricator with a large, ⅛ pint oil capacity.

ATTRACTIVE
Blends in with smooth flowing design lines . . . adds to the appearance of a machine tool.

EASY TO INSTALL
Offers in-line pipe connections—optional locations of air inlet and filter drain. Has two outlets for filtered air—one for MICRO-FOG.

EASY TO MAINTAIN
No tools needed to reach filter element or to refill oil reservoir. Back cover is removable.

Model 33AG-4
Lubro-Control Unit

- Filter
- Regulator
- Lubricator

For complete information about the new 33AG-4 unit, call your nearby Norgren Representative listed in your telephone directory—or **WRITE THE FACTORY FOR BROCHURE 556.**

MICRO-FOG® by C.A. Norgren CO.

3428 SO. ELATI ST., ENGLEWOOD, COLORADO

rotation. The brake also has a fixed excitation coil. Electomic Mechanisms, Inc., 5670 Old Post Road, Cos Cob, Conn.

For more information—
Circle 82, inside back cover

D-c Power Supply

This power supply weighs 2 lb and measures 4 x 2⅜ x 5½ in. Input of 275 v d-c provides 5000 v d-c at 300 microamp. The transformer is hermetically sealed in an epoxy resin casting and operates on 30 kilocycles. Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y.

For more information—
Circle 83, inside back cover

Interchangeable, Adjustable Caster and Glide

This ball-bearing equipped, adjustable caster and glide combination provides finger adjustment, and is designed for leveling, stabilizing and

(Continued on page 291)

protecting equipment or furniture when used on uneven floors. A self-locking adjustment permits a portable piece to be moved across the floor without the adjustment changing. The design of the caster is such that the 1⅝ in. dia phenolic wheel can swivel, yet the height adjustment remains self-locking at all times. To change from caster, screw out the wheel and screw in the glide. The phenolic-base glides are available in 1¼, 1½ and 2 in. dia sizes. Adjustable Caster Co., 1411 Walnut St., Philadelphia 2, Pa.

For more information—
Circle 84, inside back cover

Pushbutton Switch

A pushbutton switch for applications such as computers, vending machines, appliances and industrial machinery has a red plastic button which is keyed to prevent rotation, and may be detached and engraved by the user. Tapped holes allow the switch to be mounted on panels by two screws on 1½ in. centers.

Contact arrangement is single-pole, double-throw. Electrical rating of the switch is 15 amp 125 or 250 v a-c; 1 hp, 250 v a-c; ½ hp, 125 v a-c. Micro Switch, Freeport, Ill.

For more information—
Circle 85, inside back cover

Air Pressure Regulator

This regulator is a 2 in. pilot-controlled unit which reduces line pressures up to 400 psi to working pressures from 2 to 125 psi. Its temperature range is from −40 F to 200 F. The valve construction of this regulator is balanced to insure a more

(Continued on page 294)

NEW . . . All the Advantages of Norgren MICRO-FOG®
in a compact, cabinet Lubro-Control Unit

. . . FOR AIR OPERATED MACHINE TOOL COMPONENTS
• FEED MECHANISMS
• CHUCKS
• CLUTCHES
• BRAKES

FILTER REMOVES SOLIDS, LIQUIDS,
from compressed air. Choice of 64 or 25 micron filter element. Optional location of drain.

EXACT CONTROL OF AIR PRESSURE
by relieving type air pressure regulator. 150 psi. max. primary pressure —adjustable range 0-125 psi

EFFICIENT, MICRO-FOG LUBRICATION
Creates finely-divided oil fog that can be uniformly distributed to multiple lubrication points. Operating range at 80 psi is 4 to 85 cfm.

VISIBLE OIL FEED
makes possible adjustment of proper rate of oil flow. Positive proof of operation. Rate of feed accurately controlled by auxiliary air circuit.

EASY-TO-SEE OIL LEVEL
shows at a glance when oil replenishing is necessary. Easy to fill large ⅝ pint oil reservoir

QUICK MAINTENANCE
No tools needed to reach filter element or to refill oil reservoir. Back cover is removable.

Model 33AG-4
Lubro-Control Unit
• Filter
• Regulator
• Lubricator

For complete information about the new 33AG-4 unit, call your nearby Norgren Representative listed in your telephone directory—or WRITE THE FACTORY FOR BROCHURE 556.

MICRO-FOG® by C.A. Norgren CO.
3428 SO. ELATI STREET, ENGLEWOOD, COLORADO

GE VALUE ANALYSTS SAVE 80%

COMBINE SMALL GRC ZINC DIE CAST AND MOLDED NYLON MATING PARTS

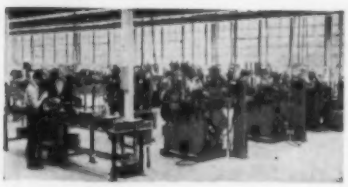
Informative Die Casting Bulletin Gives Examples, Facts from Gries

Gries' fact-filled die casting bulletin shows many examples of how GRC may help you solve your small parts problems. It also tells about GRC's design engineering services for the solution of specific problems. Send for this bulletin today or, send prints for prompt quotations on quantities of 100,000 to many millions-completely trimmed, ready to use, precision made die cast parts. Smallness of Gries die castings is unlimited; maximum weight ½ oz., maximum length 1¼ in.

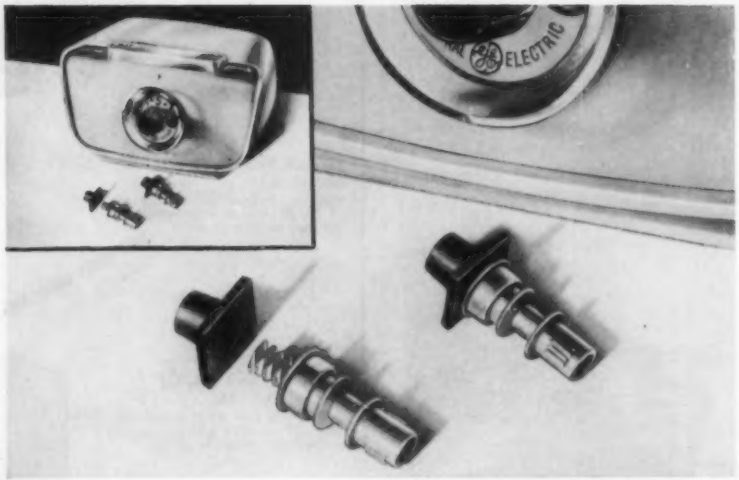
Gries' Tiny Molded Plastic Parts Offer Wide Design Latitude

The infinite possibilities offered by Gries' methods in molding tiny plastic parts offer design engineers almost unlimited latitude in their designs.
GRC molds all thermoplastics—Nylon, Kel-F, acetates, polystyrene, polyethylene, etc., with Nylon a specialty. Maximum length 1¼"; maximum weight .03 oz; minimum unlimited.
A new bulletin is now available giving complete details of Gries Plastics Molding Division. Send for it today.

Gries Reproducer Offers Complete Production Facilities



Included in the many facilities offered at the modern Gries plant are complete departments for performing secondary operations such as tapping, drilling, assembling, reaming, and special machining. Practically all commercial finishes can be applied in GRC's specialized plating department.



Gries molded nylon nut and zinc alloy die casting form mating units for GE electric blanket control part, at one-fifth the cost of the original expensive screw machine parts.

GENERAL ELECTRIC UTILIZES GRIES' INGENUITY: BUYS PARTS FOR ELECTRIC BLANKET CONTROL AT 1/5TH OF FORMER COST; GRIES TECHNIQUES ALSO IMPROVE PRODUCT'S BASIC DESIGN

Value Analysts at GE's Automatic Blanket Division consulted Gries Reproducer Corp. in an effort to lower cost and improve design of their manufactured products. One result: over 80% savings on the two intricate parts illustrated above now produced as zinc alloy die cast and molded Nylon mating parts.

Gries exclusive techniques made it possible to die cast the threaded shaft—a former screw machine part—with threads, holes and metal-saving indentations as integral parts of the casting, delivered ready-for-use.

The GRC Nylon part, formerly a special screw-machine brass nut, is now molded in one integral piece with accurate, *molded*, internal threads.

The combination not only results in superior part performance but the overall savings on these two components is over 80%.

This is only one example of the many types of savings that Gries' unique methods are affording industries in the production of better and more economical small parts.

These examples illustrate how well GRC, as a single source of supply, can precisely "mate" parts, even of different materials.

GRC again demonstrates its ability to supply industry with tiny parts at lower cost—with additional built-in economies and superior performance.

See GRC at NAT'L METAL SHOW—on stage—Booth 550

WORLD'S FOREMOST PRODUCER OF SMALL DIE CASTINGS

GRIES

GRIES REPRODUCER CORP.

159 Beechwood Ave., New Rochelle, N. Y. • New Rochelle 3-8600

ONE ENGINE

. . . with a knack for all trades!

REFRIGERATION
by *Tru Kooler*

IRRIGATION
Pump by Warren Mfg. Co.

DRILLING
Drill Rig by Carey Mach. and Supply, Inc.

AGRICULTURE
Windrower by Owatonna Mfg. Corp. and Hesston Mfg. Co.

CONSTRUCTION
Contractor's Hoist by Buck Equip. Co.

MATERIALS HANDLING
by *Sprout-Waldron*

The *FULL POWER* LYCOMING C2-90

Air-Cooled! Rated 30 h.p.—Delivers 30 h.p.!

Here's the tough, versatile engine that has an amazing variety of applications. And in this variety, the C2-90 is exposed to the most exacting working conditions . . . tested and proven in the field.

This amazing 30 h.p. unit offers you:

- The traditional air-cooled advantages of lighter weight, lower cost, all-weather performance, and superior endurance.
- FULL POWER performance—rated at 30 h.p.—*delivers* 30 h.p.!
- Highest horsepower and torque per cu. in. displacement in air-cooled field.
- Complete interchangeability—identical mounting and shaft dimensions with other major air-cooled industrial engine units in horsepower range.
- Reliability and simplicity for easy maintenance.

Yes! This engine does just what we say it will do. That's why it has been chosen by leading equipment manufacturers like those in the applications illustrated. Find out how Lycoming's 45 years of engine-building experience can solve your problems. Write:

Sales Engineering, Industrial Engines, Lycoming, Williamsport, Pa.

avco Lycoming

defense and industrial products

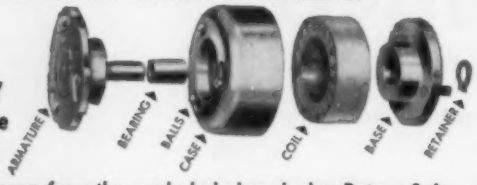
LEDEX ROTARY SOLENOIDS

GIVE POSITIVE, POWERFUL SNAP-ACTION!

Here's how a LEDEX ROTARY SOLENOID operates . . .

The magnetic pull moves the armature along the Solenoid axis. This action is efficiently converted into a rotary motion by means of ball bearings on inclined races. The inclined ball races are made to compensate for the magnetic pull increase as the Solenoid air gap closes, thereby providing substantially equal starting and ending torque during the rotary stroke. The rotary snap-action power of the Ledex can be efficiently harnessed with a minimum of linkages, through the use of one or more standard features available on all models.

Here's why LEDEX ROTARY SOLENOIDS are dependable!



As can be seen from the exploded view, Ledex Rotary Solenoids are simply constructed with few moving parts. All parts are manufactured to exacting tolerances and are carefully inspected and assembled. The copper wire coil, the heart of the Solenoid, was developed especially for this product. It is wound by a precision winding process that puts a maximum amount of magnet wire into available space . . . giving tremendous power to compact Ledex Rotary Solenoids.

Basic sizes of LEDEX ROTARY SOLENOIDS to choose from!

Model No.	2	3	4	5	6	7	8
Diameter inches	1⅛	1⅝	1⅝	1⅞	2¼	2¾	3⅜
Torque lbs.-inches	.4	1.0	1.7	4.0	7.5	25.0	54.0

Torque values for normal intermittent duty and 45° stroke.

Engineering data is available upon request.
WRITE FOR DESCRIPTIVE LITERATURE TODAY!

G. H. Leland INC.
123 WEBSTER STREET, DAYTON 2, OHIO
IN CANADA: MARSLAND Engineering Ltd., KITCHENER, ONTARIO

accurate pressure control, minimizing the effect of a fluctuating primary pressure. A pressurized chamber provides the control medium, eliminating the spring housing necessary on conventional regulators. C. A. Norgren Co., 3400 S. Elati St., Englewood, Colo.

For more information—
Circle 86, inside back cover

Subminiature Blower

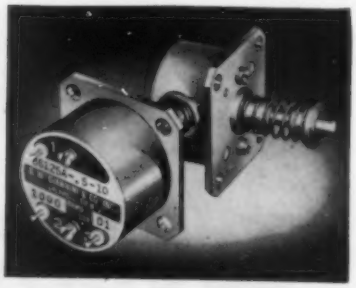
This blower uses a 1-in. dia motor. It weighs 5¼ oz. Unit operates at 115 v, 400 cps at 20,000 rpm. The 1/250 hp, single-phase motor, with 0.22 mfd capacitor, delivers 8 cfm at 1 in. back pressure.

Blower outlet is ⅞ x ⅝ in. high. Overall dimensions of blower housing are 2½ x 2⅞ in. high. Induction Motors Corp., 570 Main St., Westbury, N. Y.

For more information—
Circle 87, inside back cover

Miniature Linear Motion Potentiometer

A miniature spring loaded linear motion precision potentiometer has been designed for application re-



(Continued on page 298)

Weirzin's tightly bonded zinc coating takes the deepest draws with ease—does not crack, peel or flake under the severest fabricating operations.

Weirzin's malleable zinc coating lubricates dies without leaving a zinc deposit—reduces die maintenance—increases die life.

Weirzin, chemically treated, takes and holds paint, enamel, lacquer and lithographic ink indefinitely—eliminates underfilm corrosion.

Weirzin stops inventory losses due to rust—eliminates pickling—reduces cleaning and buffing—cuts handling before, during and after fabrication.

How to wrap up product superiority...at lower cost

Weirzin

electrolytic zinc-coated sheet

No matter how extreme the stresses of fabricating operations, electrolytic zinc-coated Weirzin stands up under them. Its tightly bonded malleable coating flows so smoothly with the ductile steel base during a deep draw that Weirzin seldom needs additional coating for corrosion protection.

Here is a different kind of steel sheet. For ease of fabricating, for durability, for long-range economy, no other "similar" metal measures up to Weirzin. Weirzin is produced in a continuous strip up to 36" wide. It is available in coils or cut lengths down to ½" strip—gauges .010 to .0478. Phone or write now for the money-saving, customer-pleasing facts about Weirzin!

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

NEW CRAMER INTERVAL TIMER features ¼ of 1% of full-scale repeat accuracy, offers wide time-range selection.

New automatic reset interval timer

Eleven full-scale time ranges—15 seconds to 24 hours—give new Cramer Type 241 versatility and precision.

Increased accuracy and operating convenience, a wide selection of time ranges, and lower costs to users are key features of the new Cramer Type 241 automatic reset interval timer.

The new Type 241 timer provides push-button starting and automatic shut-off after a predetermined time interval for a wide variety of electrically-operated equipment such as washing machines, mixers, ovens, tumbling and plating equipment, and laboratory and test equipment. Here's what it offers:

Wide selection of time ranges — 11 full-scale time ranges available ranging from 15 seconds to 24 hours.

Heavy-duty contacts — rated at 15 amperes, non-inductive load, provide capacity to handle high inrush currents.

High overall accuracy — within ± ¼ of 1% of full scale, exclusive of human setting errors.

High repeat accuracy—within ± ¼ of 1% of full scale.

Easy-to-read 3-inch dial — a fully enclosed high-visibility, black-on-white dial features 300° scale, black setting pointer and red progress pointer for easy reading and accurate setting.

Easy interval setting—large setting knob, concentric with red start button, allows rapid setting to precise time intervals. And, important at longer time ranges, setting may be changed while unit is running.

You'll find complete data on the new Type 241 timer in Bulletin PB-211. Write for your copy today. The Cramer Controls Corporation, Box 7, Centerbrook, Conn. 6.4

OUR NEW NAME

The R. W. Cramer Company has become The Cramer Controls Corporation. The reason? Simply that we outgrew the old name. We're still specialists in precision time control. And, you'll find us today ready and willing to serve you with better products and faster deliveries than ever before.

The Cramer Controls Corporation, Centerbrook, Conn.

CRAMER CONTROLS
CORPORATION

NOW

EFFICIENT FIRE PROTECTION FOR HYDRAULIC SYSTEMS WITH THESE TWO HOUGHTON FLUIDS:

HOUGHTO-SAFE 620

For all normal hydraulic temperatures and bearing loads (up to 85% of all needs)

HOUGHTO-SAFE 620 is a time-proven water-base hydraulic fluid that provides maximum protection against hydraulic fires. Its efficiency is proven by more than 4 years use in industry and over 2 years in Navy carrier catapults.

HOUGHTO-SAFE 620 has no effect on standard packings used in oil or water hydraulic systems—is not toxic—and provides greater efficiency at lowest installed cost for most hydraulic systems.

THE NEW HOUGHTO-SAFE 1020

For systems running consistently over 150°F. and for heavily loaded pumps and bearings

HOUGHTO-SAFE 1020 is a new *fortified* synthetic hydraulic fluid expressly compounded to provide greater efficiency in systems where temperatures repeatedly exceed 150°F.

HOUGHTO-SAFE 1020 provides complete rust protection; resists foaming; is stable in use and storage, low in toxicity, and high in oiliness. It's *different* from former non-aqueous fluids.

Find out today how you can now eliminate the fire hazard in any hydraulic system with the Houghton fire-resistant fluid that will provide greatest operating efficiency. Ask your Houghton Man or write to E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

HOUGHTO-SAFE

. . . products of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

For High Speeds

...this new dynamically balanced

Waldron COUPLING

An entirely new design . . . built of specially selected material . . . thoroughly tested for proper balance. Truly a precision made coupling in every respect, accurately machined to close tolerances. If yours is a high speed application, write for our descriptive Bulletin No. 52.

JOHN WALDRON CORP. • NEW BRUNSWICK, N. J.

Sales representative in Principal Cities

STANDARD TYPES

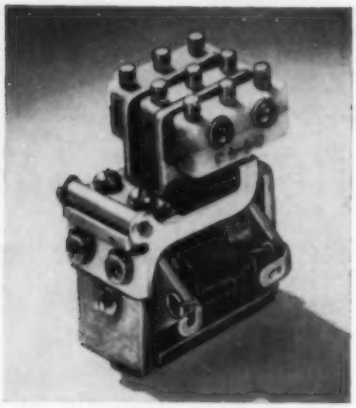
Waldron COUPLINGS

SPECIAL TYPES

quiring measurement of a short stroke in limited space. The unit is less than 1 in. long and provides ½ in. stroke of the stainless steel shaft.

Standard stroke ranges from 0.1 inch to 0.5 inch are offered in resistance ranges of 1000 and 2000 ohm with linearity of ±1 per cent and resolution of 0.0012 in. G. M. Giannini & Co., Inc., 918 E. Green St., Pasadena 1, Calif.

For more information—
Circle 88, inside back cover



Relay Drops Out Within 5 Per Cent of Pull-In

Although normally adjusted for 20 v pull-in and 9 v drop-out, an electrical residual adjustment may be made for a number of drop-out values between 9 and 19 v. This electrical residual adjustment, controlling close differential between pull-in and drop-out, may also be used in constant current circuits. Contact rating is 2.5 amp inductive and 4 amp resistive at 30 v d-c. Coils are rated from ⅒ to 6400 ohm. Sizes: 1⅝ x 1½ x 1⅜ in. wide; weight: 3 oz. Joseph Pollak Corp., Freeport St., Boston 22, Mass.

For more information—
Circle 89, inside back cover

Acrylic Resin with Improved Thermal Stability

Maximum temperature to which this formulation may be heated in a normal molding cycle is said to be greater than the molding limit of any other acrylic resin.

Because its greater stability permits

(Continued on page 300)

use steam efficiently, economically—choose the trap with . . .

big capacity

. . . for faster discharge

All a steam trap does is discharge condensate and air from steam lines and equipment—no mystery about it. The bigger its capacity, the faster it can get rid of condensate. But its importance shouldn't be overlooked. On its effectiveness can rest your economical use of steam . . . the efficiency of your process operations.

You get this high capacity in Nicholson steam traps through effective use of a large orifice. And you get much more—simplicity of design and quality through and through.

- **One moving part**
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(Continued on page 302)

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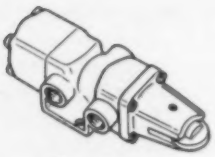

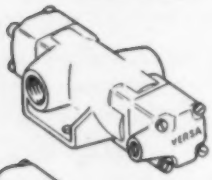

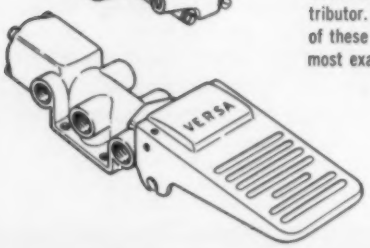

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For more information—
Circle 92, inside back cover

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For more information—
Circle 93, inside back cover

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Said to eliminate need for remote springs and extra assemblies to return load to starting position after solenoid work stroke is completed, return springs can also be used to drive loads where high starting torques occur at start of stroke and minimum impact is desired at end of stroke. The model shown operates on standard voltage, 60 cps, a-c power. Rotary

(Continued on page 306)

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*"P" Series Brakes are also available with inboard chamber mounting for special applications.

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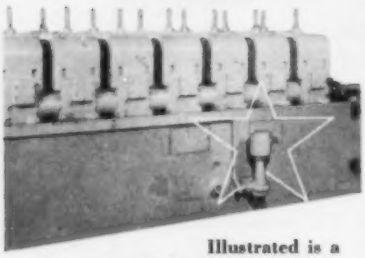

Illustrated is a Yoder Forming Mill—equipped with a Ruthman Gusher Coolant Pump.

You get instantaneous coolant flow, from trickle to full volume, the moment the machine starts, with a Gusher Coolant Pump. The electronically balanced shaft reduces wear from vibration to a minimum. The pre-lubricated ball bearings require no maintenance attention. From every angle, Ruthman Gusher Coolant Pumps are better.

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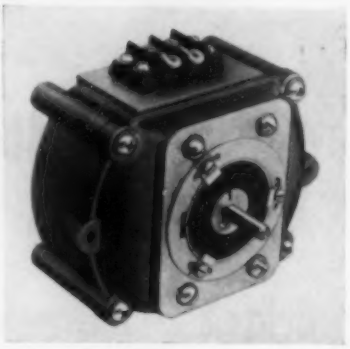
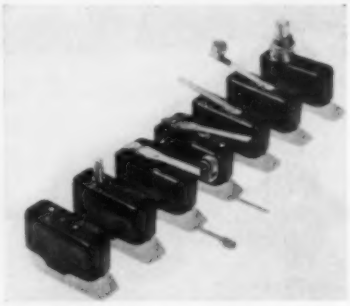


strokes up to 60 deg max are available, torques up to 75 in-lb. Continuous and intermittent duty models available. Leetronics, Inc., Dept. 96 30 Main St., Brooklyn, N. Y.

For more information—Circle 94, inside back cover



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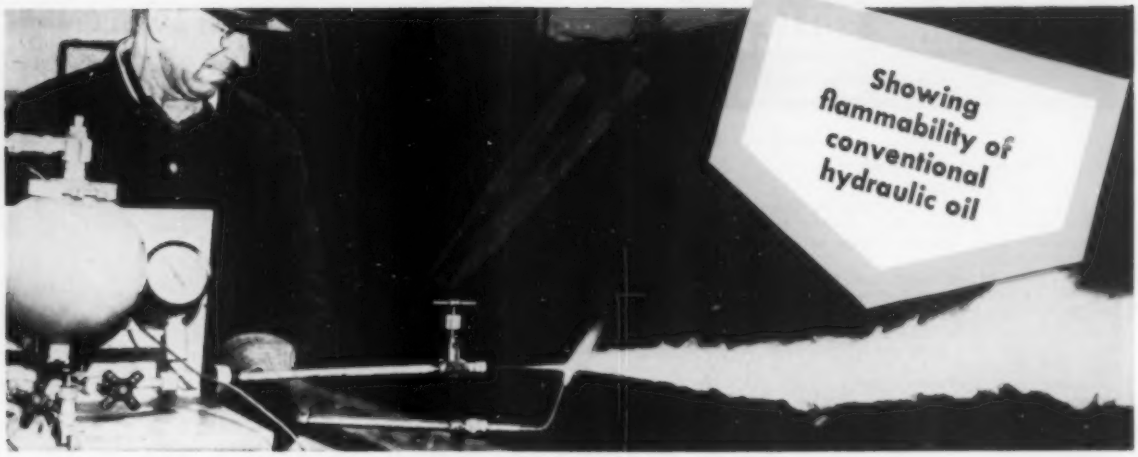
Type 10 series has a 15 amp rating; a 20 amp rating heavy duty type is also available. Licon Switch and Control Div., Illinois Tool Works, 2501 N. Keeler Ave., Chicago 39, Ill.

For more information—Circle 95, inside back cover

Electric Clutches

Made in a full range of standard sizes, both single and double types, this floating disc clutch consists of a sealed magnetic coil enclosed in the clutch housing and acting through a

(Continued on page 310)



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ENGINEERING BULLETIN
ON MICRO-BEARINGS
Miniature Instrument Ball Bearings

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH 1, NEW HAMPSHIRE

Subject: DYNAMIC AND STATIC LOAD RATINGS

DYNAMIC LOAD RATINGS

Load ratings of MICRO bearings are based on standards established by the Anti-Friction Bearing Manufacturers Association and are the result of extensive tests.

The "life" of an individual bearing is defined as the number of revolutions which the bearing makes before the first evidence of fatigue develops. Fatigue, in turn, is a function of bearing load and although other factors, such as contamination and high temperature, affect the life of a bearing, it is assumed that clean bearings running at normal temperatures are being considered.

It is not possible to predict the life of any individual bearing. The problem, therefore, is best approached by a consideration of empirically derived dispersion curves which provide a means of determining bearing life on a probability basis. That is, they permit the average life of a given group of bearings to be accurately specified.

For purposes of standardization, the "rating life" of a group of apparently identical ball bearings is defined as the number of revolutions that 90% of the group will complete or exceed before the first evidence of fatigue develops. This figure is approximately one-fifth of the average life.

If two groups of similar bearings are run under different loads F_1 and F_2 within the normal operating range of loading and rpm, their lives L_1 and L_2 are inversely proportional to the cubes of the loads, i.e.,

$$\frac{L_1}{L_2} = \left(\frac{F_2}{F_1}\right)^3$$

The BASIC LOAD RATING C is that radial load which a group of apparently identical bearings can endure for a rating life of one million revolutions, with stationary load and rotating inner ring. Within normal operating ranges the rating life for any load *is a constant number of revolutions*, so the following relationship, a restatement of the inverse cube proportion, may be used to compute rating life when basic load rating and applied radial load are known:

$$L = \left(\frac{C}{P}\right)^3$$

L = rating life in millions of revolutions
where, C = basic load rating in pounds
P = applied radial load in pounds

The nomograph illustrated permits the quick evaluation of any one of the three quantities when the other two are known. For example, if the C rating of a given bearing is 95 pounds, and the bearing is loaded radially with 12 pounds, P, a straightedge crossing these two values in their respective columns shows that the bearing could be expected to have a life, L, of 450 million revolutions.

DEFINITION OF EQUIVALENT LOAD

Bearings whose loads are primarily radial are usually also subjected to axial forces. When the axial component of the load is greater than a negligible value, this combined radial and thrust load may be expressed in terms of a simple radial load in order that the basic load rating C may be calculated. This simple radial load is known as the "equivalent load", which is that constant stationary radial load which, if applied to a rotating inner ring, would give the same life as that which the bearing will attain under the *actual* conditions of load and rotation.

FORMULA FOR EQUIVALENT LOAD

For conventional bearing types other than those with filling notches, the equivalent radial load is given by the maximum of the two values:

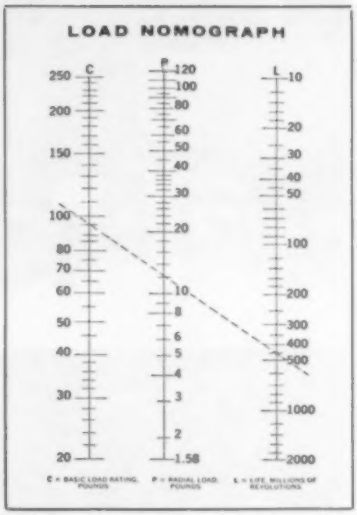
a) $P_r = VF_r$ — X is a radial factor
b) $P_r = XVF_r + YF_a$ — Y is a thrust factor
where, V is a rotation factor; F_r is the radial load; F_a is the thrust load

The factor e represents the ratio of $\frac{F_a}{VF_r}$ for which the two equations are equal. If the ratio of loads is such that $\frac{F_a}{VF_r} \leq e$ then formula (a) is used: if $\frac{F_a}{VF_r} > e$ then formula (b) is used.

For inner ring rotation V = 1.0 in all cases; for outer ring rotation V = 1.2 in all cases except for self-aligning bearings, where V = 1.0. In most calculations involving MICRO bearings, the following values are sufficiently accurate: X = 0.30, Y = 1.04, and e = 0.67. In the case of self-aligning bearings, however, X = 0.40 and Y = 7.6.

In practice, the angular contact type of bearing should not be subjected to a predominantly radial load unless opposed by another bearing.

When a bearing is loaded and at rest the dynamic life formula $\left[L_N = \left(\frac{C}{P}\right)^3\right]$ cannot be used because when $L_N = 0$ then $P = \infty$. Obviously there is a limit to the Static load which the bearing can carry, this limit being determined by permanent deformations which develop in the load carrying surfaces. Such deformations appear even under very light loads and increase gradually with increasing load, with no sharply defined limit beyond which they begin. The static load limit is dependent on the permissible magnitude of deformation, consistent with requirements of quietness and freedom from vibration. Experience indicates that a permanent deformation in the raceway of less than 0.0001 times the diameter of the rolling elements ordinarily has no objectionable influence on the functioning of the bearing.



In order to obtain an expression for the load carrying capacity at rest, and a numerical value that can be used as a reference, the pure radial load which corresponds to this negligible magnitude of permanent deformation has been selected as the basic static load rating and given the designation C_o.

If the load is much higher than C_o when the bearing is not rotating, minute depressions are formed in the raceways, causing the bearing to be noisy and to vibrate when operating at high speed, even though the bearing friction is not noticeably increased or the bearing otherwise injured. Depending on the requirements in this respect, the static load may occasionally be allowed to exceed the C_o value.

If a load considerably higher than C_o acts only while the bearing rotates, the permanent deformations that occur will be evenly distributed in the raceways and cause no serious impairment until the deformations become relatively large. However, under such a heavy load, the fatigue life will be comparatively short in terms of the number of revolutions. Static load rating values for all MICRO bearings are presented in our catalog-data book.

FIG. 1. *Typical cut-away views of instrument-type retainer ball bearings. Complete tabular data on "C" factors and static load ratings are contained in the MICRO Bearings Catalog.*

DESIGN HANDBOOK OFFERED *FREE*

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Write to: New Hampshire Ball Bearings, Inc., Peterborough 1, N.H.

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Photo courtesy Lees Bradner Company, Cleveland, Ohio.

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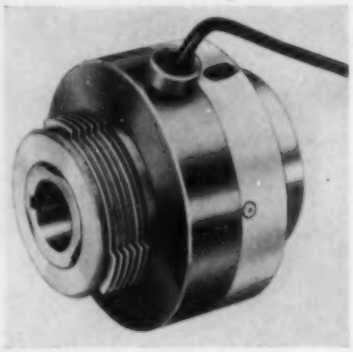

sleeve and pressure plate to compress the clutch discs. The electro-magnetic actuating mechanism is stationary.

All sizes of the clutch operate on 110-v house current, rectified to 90 v d-c current, and they consume 80 w. Carlyle Johnson Machine Co., Manchester, Conn.

For more information— Circle 96, inside back cover

Valve-In-Head Cylinder

The solenoid in this unit is designed for 110 v, 60 cps continuous operation and its operation controls the movement of the cylinder rod when air is brought to the single port on the unit. Breaking the electrical contact returns the rod to its original position. The cylinder will operate on air

(Continued on page 314)

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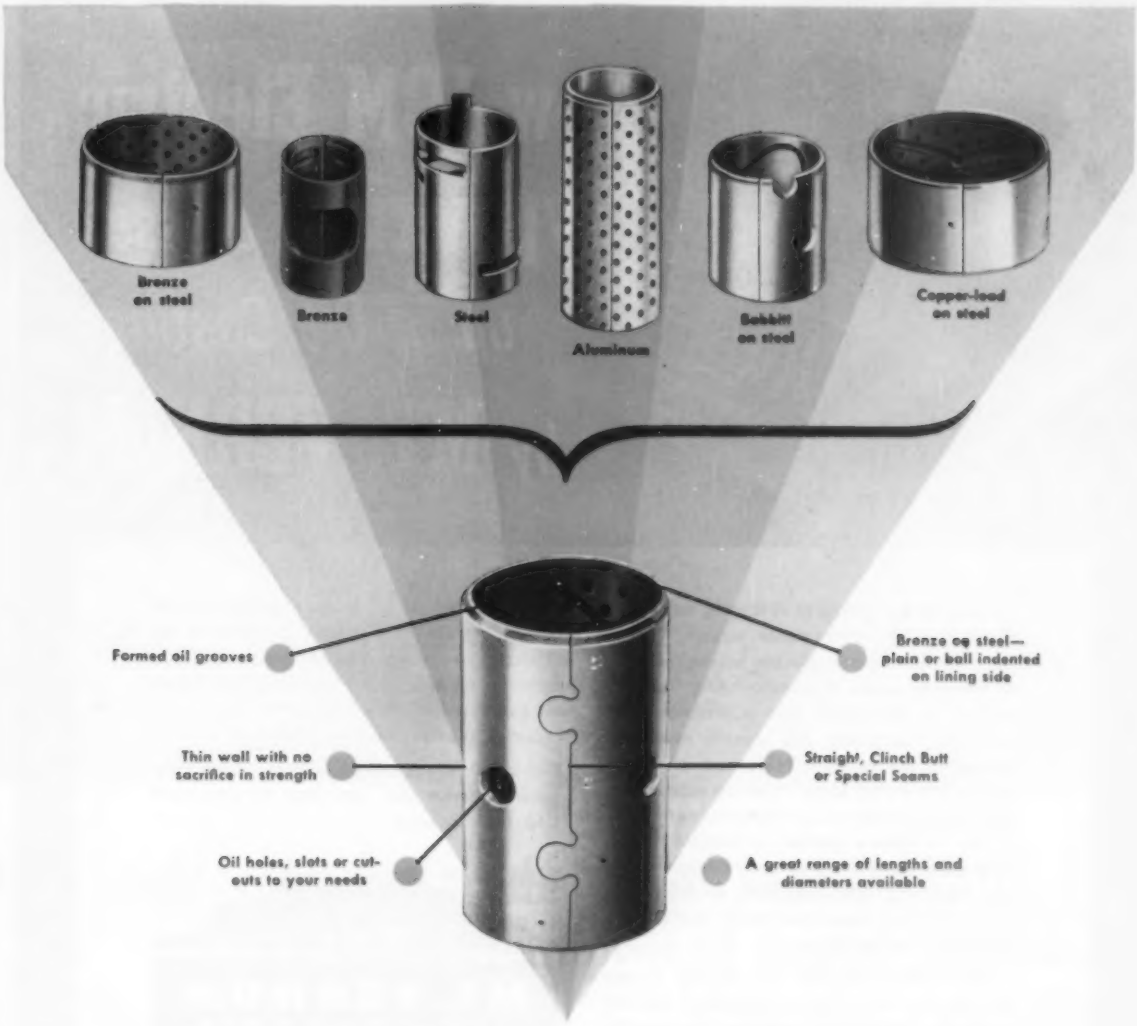
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Thin wall with no sacrifice in strength
Oil holes, slots or cut-outs to your needs
Bronze on steel—plain or ball indented on lining side
Straight, Clinch Butt or Special Seams
A great range of lengths and diameters available

Bearing Performance with Bushing Economy

Any of these design features can be incorporated in our plain or bi-metal bushings. For many applications lower cost bushings provide the needed bearing characteristics at a distinct price advantage. We provide a complete engineering service. Address:

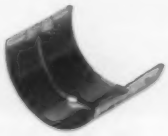
FEDERAL-MOGUL

DIVISION, Federal-Mogul-Bower Bearings, Inc.
11043 Shoemaker, Detroit 13, Michigan

BABBITT-LINED BEARINGS

BEARING-SURFACED THRUST WASHERS

SPACER TUBES



COPPER-LEAD BEARINGS

FEDERAL Mogul

SINCE 1899

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

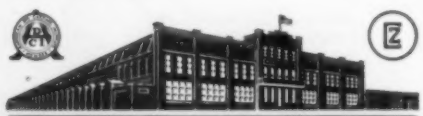
New IBM Electric Typewriter *dressed up in Die Castings* by MT. VERNON

CASE HISTORIES FROM MT. VERNON FILES

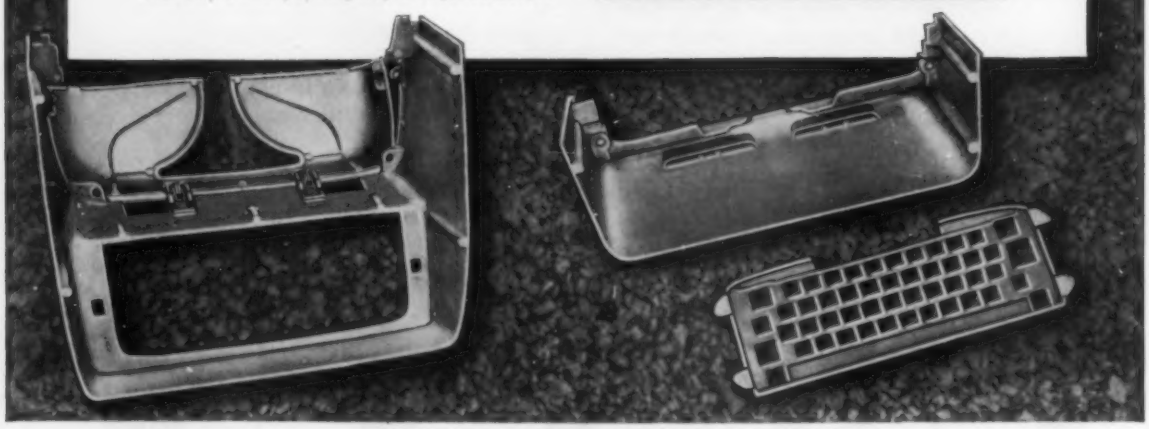
"New from carriage to keyboard, and years ahead in results, performance, design," is how IBM describes its new electric typewriter. And as with any leader in manufacturing, "new in design" at IBM means best in manufacturing methods. That's why this electric marvel is housed in die castings. Note how only four strong, thin-walled, large aluminum sections are used to completely enclose the complex machinery in a handsome example of modern styling. Note particularly the accurately-fitting sections and keyboard, and gracefully-rounded contours, always a delight to the eye, but often a manufacturing headache.

Not so, however when you use Mt. Vernon die casting — the modern, high-speed, low cost production method that produces the most intricate parts, frequently so flawlessly perfect that only a final painting step is required before assembly. Best of all is the complete service available from Mt. Vernon's coordinated designing, die-making, casting, and machining facilities, all under one roof, which can supply die cast zinc and aluminum parts ready for use; reducing need for machining and finishing.

A switch to die casting or to a complete die casting service like ours, may be your next step. Let's discuss it.



MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT



SALES REPRESENTATIVES

Mr. Grant Eller
6 East 194th St., Cleveland, Ohio

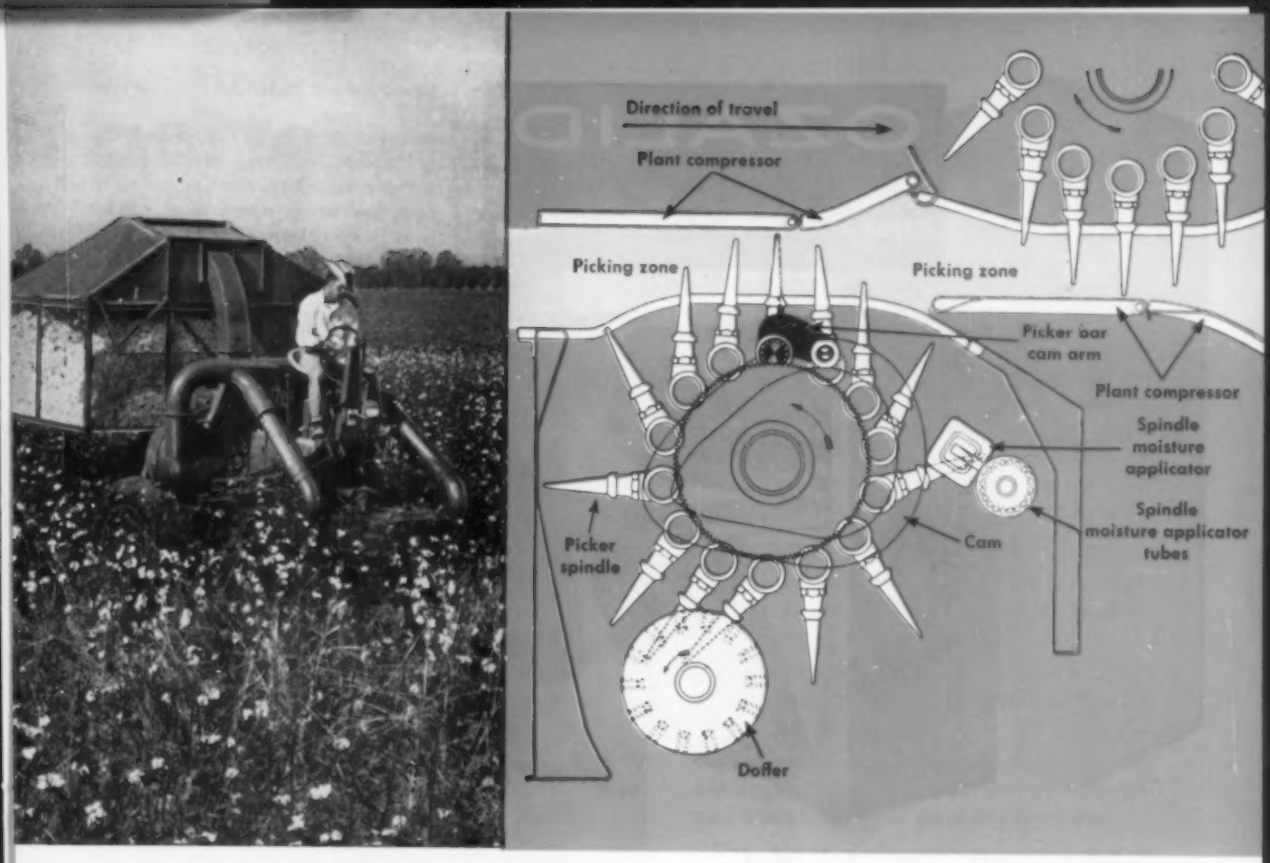
Mr. David King
230 Grant Boulevard, Syracuse, N. Y.

Mr. William Sauers
101 Briarcliff Road, Rochester, N. Y.

Mr. Arthur Diamond, Tools Incorporated
86 Bethlehem Pike, Philadelphia, Pa.

Mr. Jerome J. Theobald
9 East Genesee St., Skaneateles, N. Y.

Mr. George E. Hahl
39 South Munn Ave., East Orange, N. J.



How angular power transmission makes still another improved design practical

This cotton picking machine is just one of many, many products improved and made more practical through the flexibility of angular power transmission.

Using the angle of transmission shown at right, the makers of the machine can put a whole roll of spindles on a bar and drive them with a single source. The spindles pluck bolls gently from the cotton plant and deliver them unmarred to a collecting basket.

Besides this flexibility, bevel gear transmissions usually weigh less, cost less, and carry heavier loads.

Our engineers are ready at all times to help you work out applications for bevel and hypoid gears.

They can discuss such items as mountings and lubrication. They can produce and test prototypes of your drives.

Finally, they can advise you on the proper machinery to use to produce top quality gears in large quantities at low costs.

Please write whenever you have an application in mind.

Meanwhile, you'll find these Gleason Technical Handbooks helpful:

20° straight bevel gear system
Spiral bevel gear system
Zerol® bevel system

The cotton picking machine shown above, uses 420 of these tapered spindles in its picking drum (diagram). The machine slashes picking costs by as much as 60%.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

Big machine volume and speed in this compact new

PRINTMASTER 810

Sturdy, compact, smartly styled, the new medium-priced Printmaster 810 has *everything*—easy, low-cost operation, high speed and *big machine* production capacity.

It prints and develops in one continuous operation at speeds up to 40 feet per minute . . . easily handles roll or cut stock as wide as 42 inches. Easy-to-reach controls command quick response throughout the machine's entire operation. Developing and printing sections are automatically synchronized for simplest operation at any speed.

Complete diffusion of vapors through exclusive "jet-nozzle feed" insures uniform, dry, fully developed prints. Spacious receiving trays automatically stack prints in sequence. Electrically welded one-piece assembly stands 61" high, 61" wide, 42" deep (including feedboard).

See and try the Printmaster 810 yourself. Call your nearest Ozalid distributor for a demonstration. His number's in the phone book, or write Ozalid, Dept. 0-10, Johnson City, N. Y., for descriptive brochure.

OZALID®
DIRECT COPY SYSTEMS

A Division of General Aniline and Film Corporation
In Canada, Hughes Owens Co., Ltd., Montreal

LOOK FOR IT!

Got A Printmaking Problem? Call your local Ozalid representative. His expert advice is yours for the asking—whether or not you now own or plan to buy Ozalid equipment.

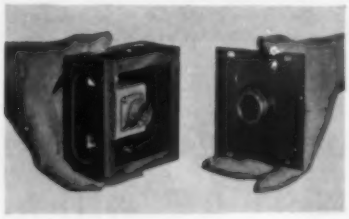
pressures of 5 to 150 psi and the valve, itself, will cycle at 800 strokes per minute. The valve is an air-return, four-way type and no springs are used in its construction. A. K. Allen Co., 57 Meserole Ave., Brooklyn 22, N. Y.

For more information—
Circle 97, inside back cover

Hydraulic In-Line Relief Valves

A line of relief valves has been developed for airborne oil-hydraulic applications that combine unusually accurate control and fast response with exceptionally "flat" performance characteristics. Designed for use in 3000 psi systems having operating temperatures up to 650 F, the valves are available in ¼, ⅜, ½ and ¾ in. tube sizes. Vickers Inc., Box 302, Detroit 32, Mich.

For more information—
Circle 98, inside back cover



Spherical Orientation Electrical Connector

This rack and panel connector, which will self-align and mate in blind connections, has three integral keys, keyslots and compression springs. The self-aligning is possible without match plates or guidance pins. The connector, available in 19 and 37-contact models, is operative from −67 F to 250 F. Deutsch Co., 7000 Avalon Blvd., Los Angeles 3, Calif.

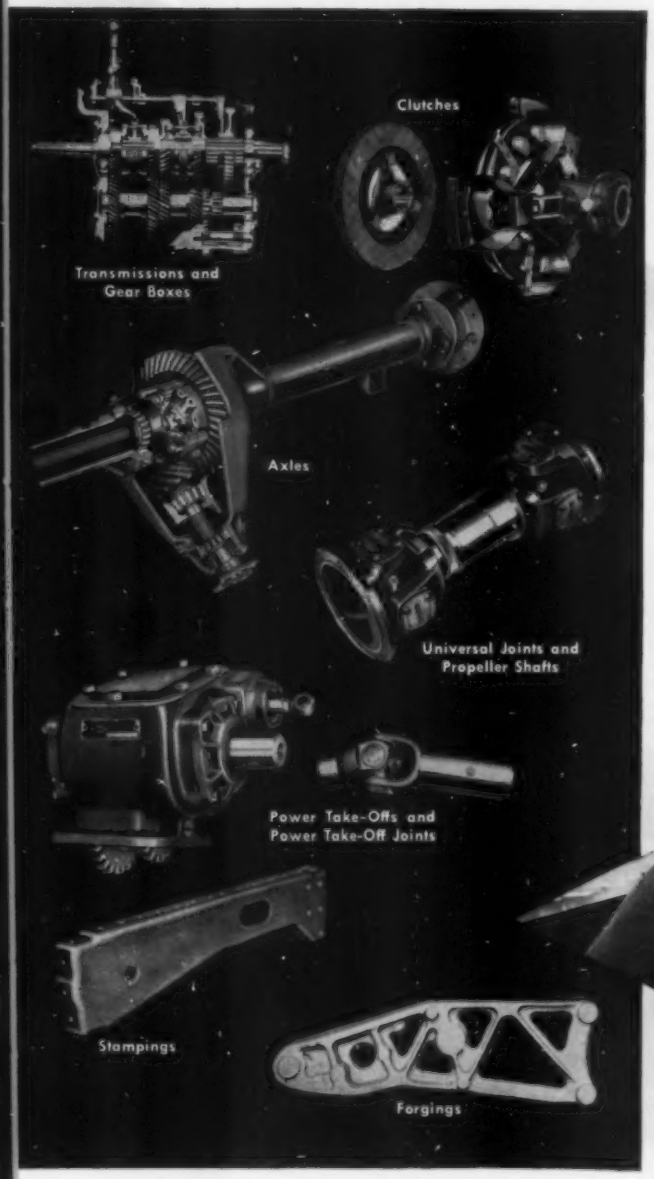
For more information—
Circle 99, inside back cover

Grommet Seal

A grommet seal has been designed especially for liquid pumps, freon compressors. It is said to permit replacement of defective packing-type seals without changing a worn shaft. Close hydraulic balance permits high

(Continued on page 318)

DANA specializes in the design and manufacture of many different Spicer products



Notice the wide variety of Spicer power transmission units shown at the left—the result of 52 years in the development and manufacture of such products for use in railroads, airplanes, ships, industrial machinery, automobiles, trucks, buses, and a great variety of other power transmission purposes.

DANA can help you adapt these Spicer units to your particular needs.

DANA can help you by developing specialized Spicer units suited to your individual requirements.

DANA can help you develop new and improved products for greater operating efficiency and wider sales appeal.

DANA can help you with a corps of designers and engineers offering wide power transmission knowledge from years of experience.

Dana has 10 modern plants for efficient production in strategic locations. Write for booklet describing DANA facilities, and ask us to consult with you on power transmission problems.

DANA CORPORATION

Toledo 1, Ohio

SPICER PRODUCTS: Transmissions, Universal Joints, Propeller Shafts, Axles, Torque Converters, Gear Boxes, Power Take-Offs, Power Take-Off Joints, Rail Car Drives, Railway Generator Drives, Stampings, Spicer and Auburn Clutches, Parish Frames, Spicer Frames, Forgings

Spicer

Experience in Engineering *Ability in Manufacturing*

FIRST IN PULLEY DESIGN!

Free ALL limitations with LEWELLEN VARIABLE PULLEYS COMBINATION PULLEYS

MAX. PITCH DIAMETER POSITION

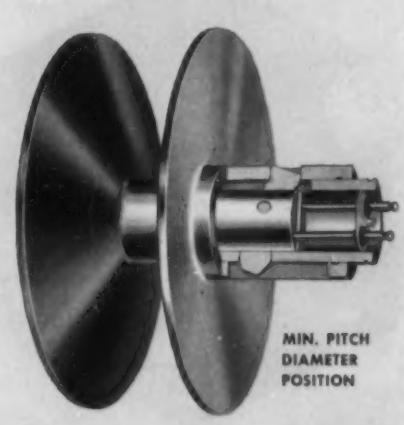
LEWELLEN DESIGN

These cut-aways show the basic Pulley. Add spring and covers to make the self-VARIABLE PULLEY. Add paired ball bearings and housings to make the manually-ADJUSTABLE PULLEY.

The sleeve, bored for motor shaft, mounts the pair of discs with their slotted hubs. The pivoted, contoured key both rotates and positions the discs.

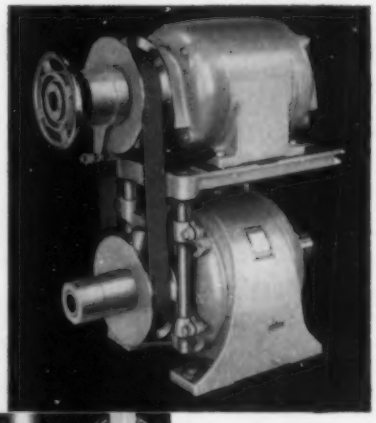
The spring—or ball bearings—independently thrust the discs, directly and equally, in driving engagement with the Variable Belt.

Each disc is separately lubricated through vented channels.



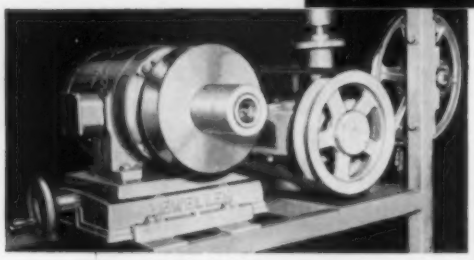
MIN. PITCH DIAMETER POSITION

Operate in any position – horizontal or vertical – up or down . . . Motor and machine shaft may point in the same or opposite directions . . . Your shafts mount the Pulleys – no supporting bracket required . . . Infinitely variable speeds are directly applied and conveniently controlled – performance is smooth, dependable . . . Loading of Pulleys is self contained – no thrust load on motor or machine shaft bearings . . . Pulley discs are symetrically, positively positioned – Variable Belt tracks in true alignment, without skew or offset, and with full traction for all speeds . . . Fixed path of Variable Belt permits driving to flat or crowned pulley, or to sheave.



Lewellen Combination Pulleys with Foote Vari-Mount Reducer and standard motor. Standard components comprise an accessible, compact, motorized variable-speed unit.

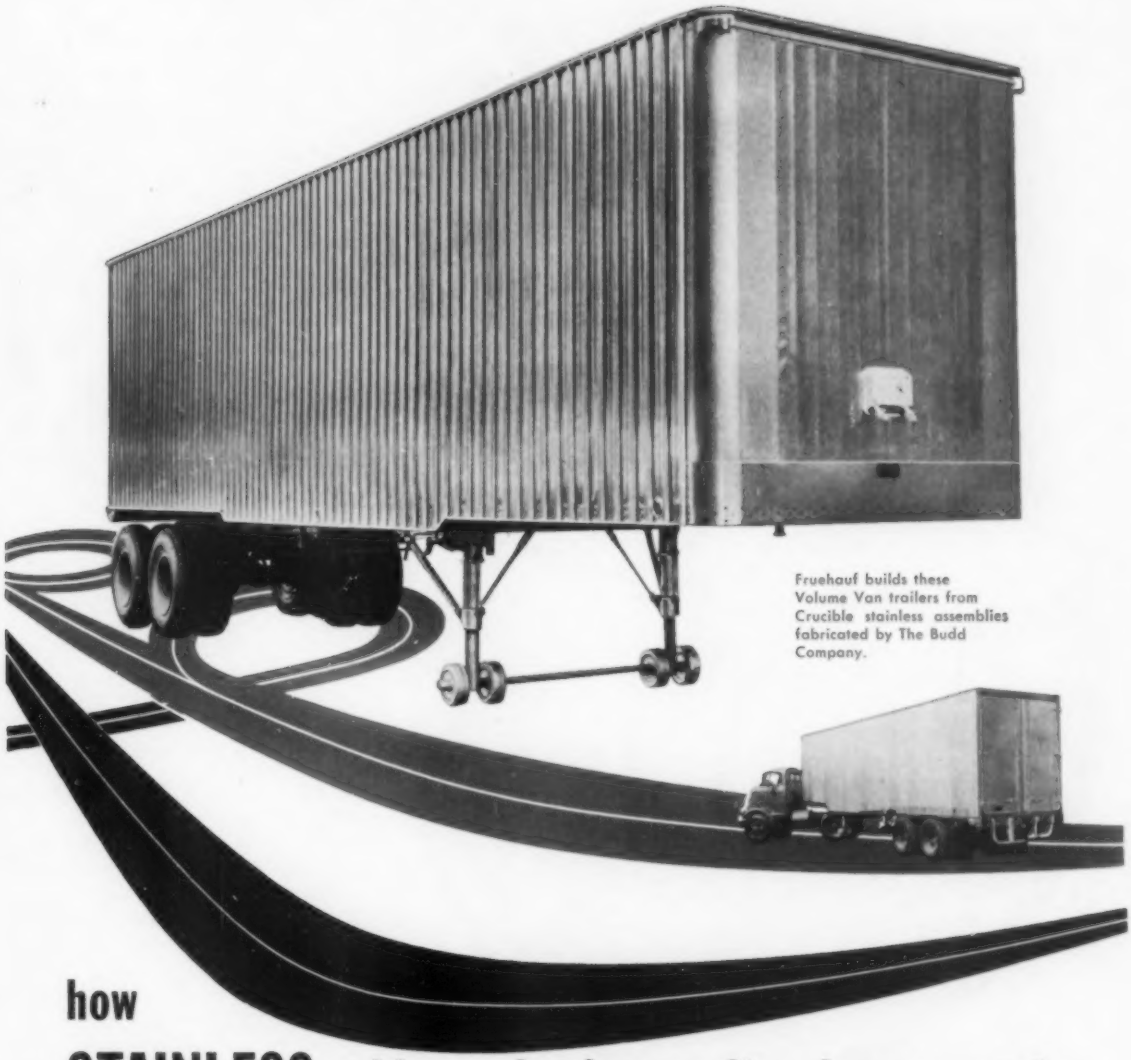
Lewellen Variable Pulley and Adjustable Base incorporated with Fowler-Minder Filler Machine, manufactured by Quality Machine Co.



WRITE FOR CATALOG NO. 60-A
Complete new section on combination pulleys

LEWELLEN MANUFACTURING CO. COLUMBUS, INDIANA

Distributors In All Industrial Areas • In Canada – Peerless Engineering Sales Ltd. Toronto – Montreal



Fruehauf builds these Volume Van trailers from Crucible stainless assemblies fabricated by The Budd Company.

how STAINLESS adds payload capacity—lowers costs

Cargo capacity and profits go hand-in-hand in the transportation field. And stainless steel's high-strength gives this Fruehauf *Volume Van* trailer construction advantages that add up to carrying capacity above that of other van type trailers.

Stainless steel provides extreme rigidity and toughness, yet reduces dimensions of side walls, roof tension sheets, and front and rear panels. As Fruehauf says:

"Not only is there a gain in cubic capacity as well as strength, but an actual saving in weight so that the net result of the complete design is a transportation unit which will provide the highest possible return on the initial investment."

And stainless lasts indefinitely. In fact, there's a tradition in the industry that "no stainless steel trailer has ever worn out." For stainless resists wear, fights corrosion, takes a lot of punishment before it will scratch or dent. Maintenance is greatly reduced.

Should your product use stainless? It may be the answer to greater efficiency, lower costs, a more attractive product for you, too. Ask your local Crucible representative, or write *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

A major development in small motor brushes

Stackpole Grade 373 fractional h.p. brushes show materially longer life coupled with minimum commutator wear. Ideally suited to cleaners, food mixers, sewing machines, calculators and similar motorized equipment, they are typical of progress achieved in Stackpole's continuing brush development program.

Brush headquarters for every type of rotating electrical equipment . . . backed by a half a century's specialized experience in developing and producing dependable carbon-graphite and metallic powder materials and components.

STACKPOLE CARBON COMPANY, ***St. Marys, Pa.***

Plants: **St. Marys, Penna. (2) . . . . . Kane, Penna. (3) . . . . . Johnsonburg, Penna. . . . Canadian Stackpole, Toronto, Ont.**

liquid pressure. Available in 6 standard sizes adjustable to any lengths with broad axial tolerances. Cartriseal Corp., 3515 Touhy Ave., Lincolnwood, Ill.

For more information—
Circle 100, inside back cover

Governor for Torque Converters

The use of the flyball system in these torque converter governors provides control of tailshaft speeds throughout a broad range in all types of applications. These governors are readily adaptable to all converters having provisions for driving a governor directly, with a belt, or with a flexible cable. Pierce Governor Co. Inc., Anderson, Ind.

For more information—
Circle 101, inside back cover

Miniature Flexible Coupling

A miniature coupling for motors and other small units is rated at 1/20 hp at 1750 rpm. The full range is from 0.003 hp at 100 rpm to 0.103 at 3600 rpm. Dimensions are $\frac{3}{8}$ x $\frac{3}{4}$ in.

(Continued on page 321)

"More Than A Metal—It's A Method"

NICKELOID METALS

The Nickeloid Method Eliminates Three Costly Production Steps

Out of the shipping crates — directly into your fabricating process . . . Your production line gets shorter when you take advantage of Nickeloid Metals to produce plated metal components and trim.

Durably, uniformly PRE-plated in 14 finish-to-base metal combinations, these modern metals are ready for immediate fabrication when they arrive at your plant. They require no additional cleaning, plating or polishing — just fabricate and assemble. You by-pass 3 out of 5 basic production steps . . . cut costs up to 20 per cent. Production speed is only one of the reasons why production-minded manufacturers specify Nickeloid Pre-Plated Metals. Improved quality, versatility, functional beauty and the basic production economies of the Nickeloid Method are additional advantages which are being proved every day on production lines in a wide range of industries.

It will pay you to investigate . . . specify Nickeloid Metals.

SEND FOR FREE FABRICATION AND DESIGN BOOKLET

24 pages of illustrations and reference-type material covering uses, properties and fabrication techniques for Nickeloid Pre-Plated Metals.

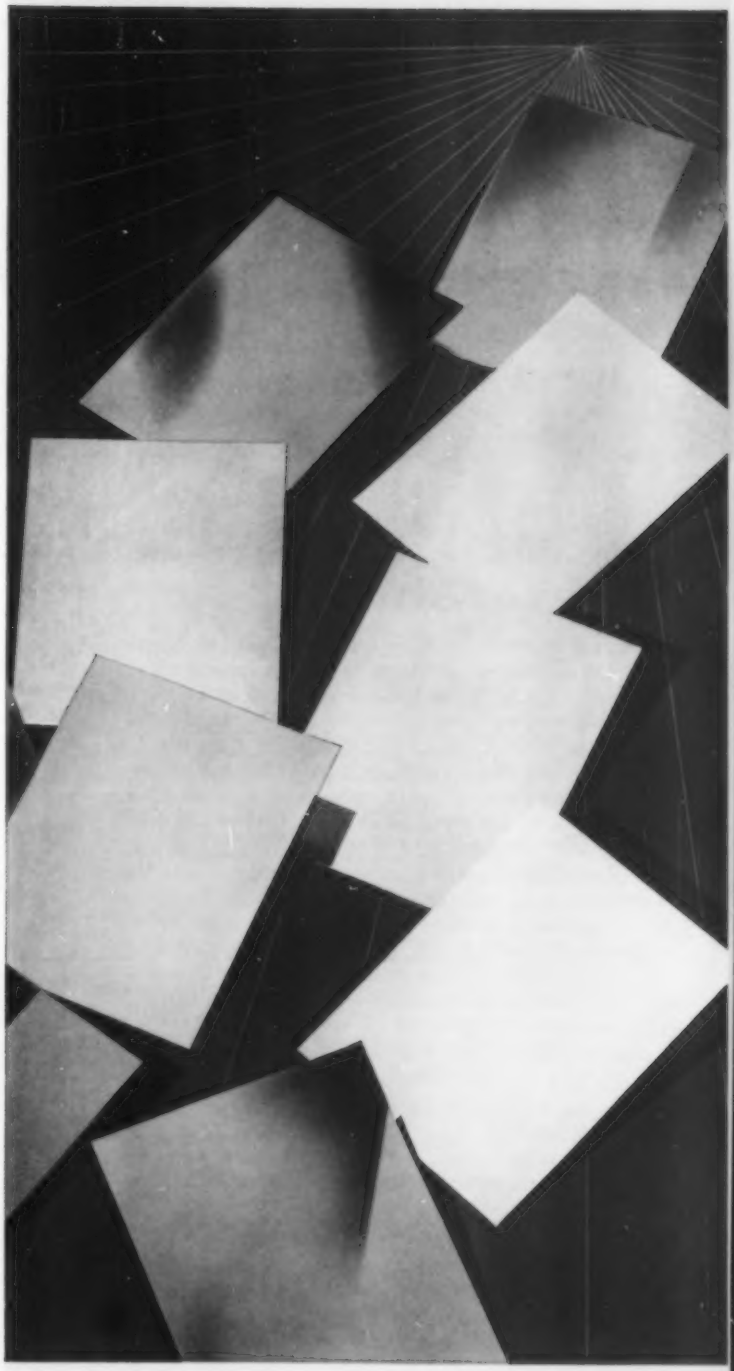
NICKELOID METALS

SINCE 1898

AMERICAN NICKELOID COMPANY

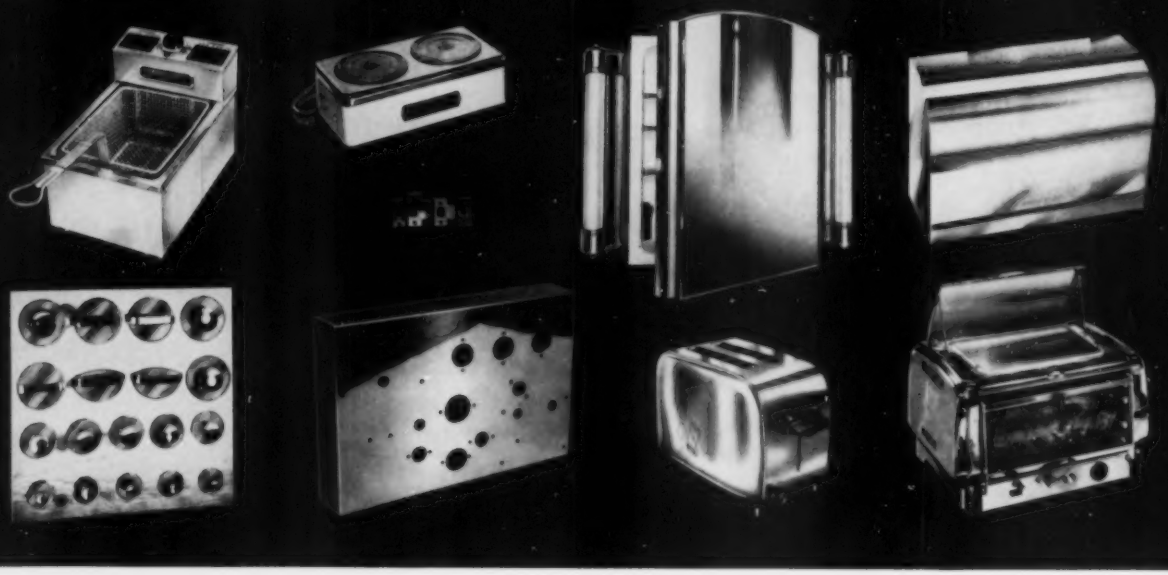
Administrative Office: Peru 4, Illinois

MILLS: Peru, Ill. and Walnutport, Pa.



Nickeloid Metals are available in sheets, coils and strips, with uniform pre-plated finishes of chrome, nickel, copper and brass on base metals of steel, zinc, copper, brass, aluminum.

Cost-Saving Applications Of Pre-Plated Metals



How and Where to Use Pre-Plated Metals

Because of their versatility and adaptability to various design and production techniques, any list of applications of pre-plated metals could run the gamut from door hardware, striker plates and fish lures to broiler-rotisserie wrap-arounds and cannister sets. Experience has shown that where the design engineer considers a pre-plated metal as his design material in the "pre-planning" stage, these modern *finished* raw materials perform admirably . . . both as eye-pleasing decorative trim and functional parts.

For small or complex parts — for small stampings — or where it is virtually impossible to polish interior and hard-to-reach surfaces and contours, pre-plated metals are ideally suited. Indeed, many design features are conceived "around" pre-plated metals . . . features which would be impossible without the pre-plated method of production. After the part is fabricated it can be assembled right into the finished product — requires no post-plating or organic finishing — no degreasing, washing, rinsing, drying.

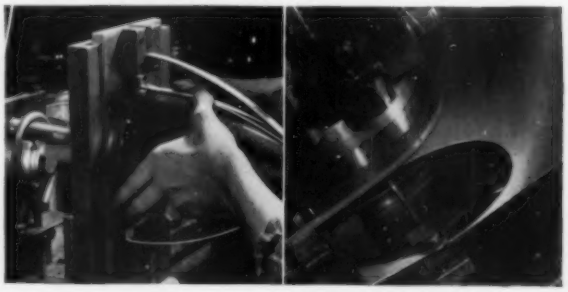
The resultant saving in time, manpower and equipment is considerable and quality of output is usually higher and more uniform. Your plating and finishing problems are reduced to merely selecting from among the many finish-to-base metal combinations, the pre-plated metal best suited to your application.

With reasonable care and good shop practice, pre-plated metals can be fabricated in much the same way as unplated metals. There is no need to invest in special handling and fabricating equipment.

Blanking is performed the same as with plain metals except that close inspection of punch and die is required to detect and eliminate rough edges.

In drawing, if the amount of draw is sufficient to cause a dulling or "orange peel" effect on an unplated metal it will cause the same effect on a plated metal. Hydraulic press operation is preferable to mechanical press.

Bends up to 90 degrees can be made with or against the base metal rolling grain without surface dulling, provided that radii are sufficiently large.



Pre-plated metals can also be seamed, welded, soldered, riveted and etched with excellent results.

Where severe forming is required, Nickeloid metals may be furnished with either of two kinds of protective coating, called, Mar-Not. One type is a strippable plastic film which is sprayed on and stretches when the metal is fabricated. The other is a pressure sensitive paper adhered to the metal by a special gum. Either can be easily peeled off after fabrication.

Assistance in designing and fabricating with pre-plated metals — working metal samples, too — is available from **AMERICAN NICKELOID COMPANY.** *See preceding page for free fabrication and design booklet.*

overall length. Bore sizes are $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$ and $\frac{5}{8}$ in.

Bodies are standard in die cast aluminum but can also be furnished in brass. Spiders are one-piece spider type and are made from a resilient Buna-N compound. Lovejoy Flexible Coupling Co., Dept. PEN, 4801 W. Lake St., Chicago 44, Ill.

For more information—
Circle 102, inside back covre

Non-Flammable Wax-Type Coating

The product is a water emulsion of waxes and oils in combination with selected corrosion inhibitors which, when applied to metal surfaces, provides a protective film. When applied by dip or spray, a uniformly firm, wax-type coating is formed. After a brief drying and curing period, this coating cannot revert to emulsion, nor will it wash off during outdoor exposure. Dearborn Chemical Co., Merchandise Mart Pl., Chicago 54, Ill.

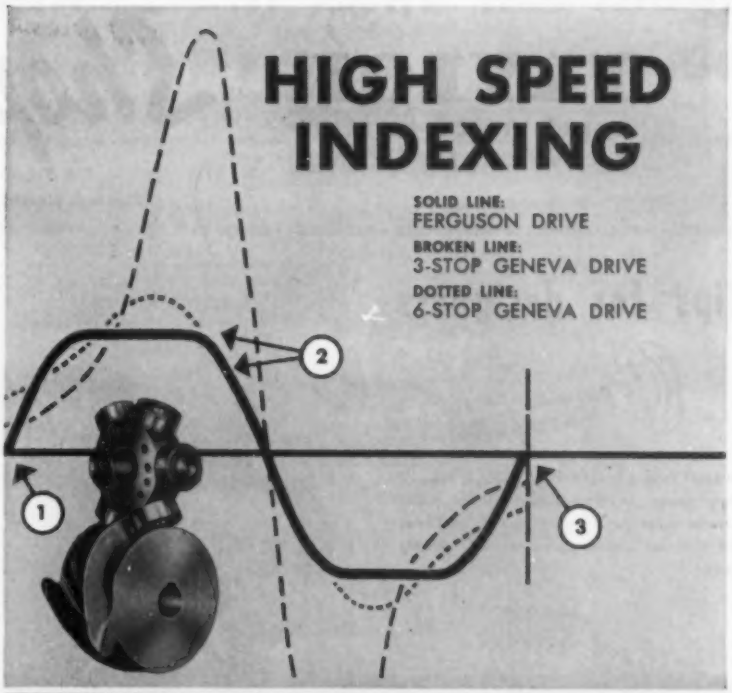
For more information—
Circle 103, inside back cover

Limit Stops

The limit stop either halts shaft rotation by purely mechanical means or uses electrical switches to cut power at the appropriate moment. This line of electro-mechanical assembly components includes three basic types. The wafer limit stop is used when the load is comparatively light and a small number of turns are to be controlled. The limits of shaft rotation are set by the number of angular wafers placed on the shaft. Each wafer permits 300 deg rotation. The full complement of 21 wafers will allow slightly less than 17 turns.

The lead screw mechanical stop is used when a large number of turns are to be controlled, when the load may be heavy or when severe shock is expected as shaft rotation is halted. Shaft rotation limits are set by the difference in position of the stops on lead screw. Each inch of separation permits thirty-two turns. Three models are available, differing only in length and maximum number of turns per-

(Continued on page 324)



FERGUSON DRIVES VS. GENEVA DRIVES

MODIFIED TRAPEZOID ACCELERATION CHARACTERISTIC OF THE FERGUSON DRIVE PERMITS SPEEDS UP TO 1,000 INDEXES A MINUTE!

The acceleration diagrams above show why it is practical to operate the smooth indexing Ferguson Drive at a rate far beyond that of the obsolete geneva drive. As every engineer knows, the geneva limits the speed of production machinery . . . the clanging, banging and jarring wears out the geneva drive and the machine, and affects product quality.

Now see how the Ferguson Drive differs!

1. *The Ferguson Drive has an initial force of zero with a sinusoidal increase . . . the start of the movement is smooth.* Genevas have instantaneously applied dynamic forces, followers "crash" into slots, whatever accuracy existed is soon lost.
2. *The Ferguson Drive, utilizing a combined cycloidal and gravity curve, has a very low maximum acceleration value with a gradual change to maximum deceleration.* The geneva has a high maximum acceleration value with an almost instantaneous change. Vibrations from the geneva drive decrease efficiency of the machine and create a need for excessive maintenance.
3. *Deceleration and stopping of the Ferguson Drive is gradual.* Geneva drives decelerate suddenly . . . they practically "jerk" to a stop and the shock is tremendous at high speeds.

Differences in precision, life expectancy and design versatility of the two types of mechanisms are equally striking. They are discussed in our new Catalog 106 on STOCK AND STANDARD FERGUSON DRIVES. Send for your copy if you are an engineer interested in learning about high speed indexing methods.

USE THE FERGUSON DRIVE FOR INDEXING DIALS, ROLL FEEDS, CARRIERS & CHAIN . . . WHEREVER YOU NEED HIGH SPEED, PRECISION INDEXING

ferguson

FERGUSON MACHINE CORPORATION

ROLLER GEAR DIVISION, DEPT. P-10 P. O. BOX 5841, ST. LOUIS 21, MO.

TAYLOR Shop Talk

Laminated Plastics
Vulcanized Fibre

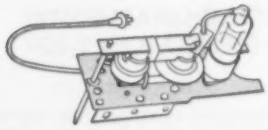
TAYLOR FIBRE CO.
Plants in Norristown, Pa. and La Verne, Calif.

PHENOL—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • COPPER-CLAD LAMINATES • VULCANIZED FIBRE

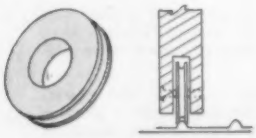
Tips for designers

Aircraft fuel gage tank unit uses a tube of Taylor epoxy glass base laminate . . . an unusual material noted for excellent corrosion resistance and electrical insulation over a wide humidity range.

Welders' helmets are fabricated from tough durable Taylor vulcanized fibre . . . readily formed to many desired contours.



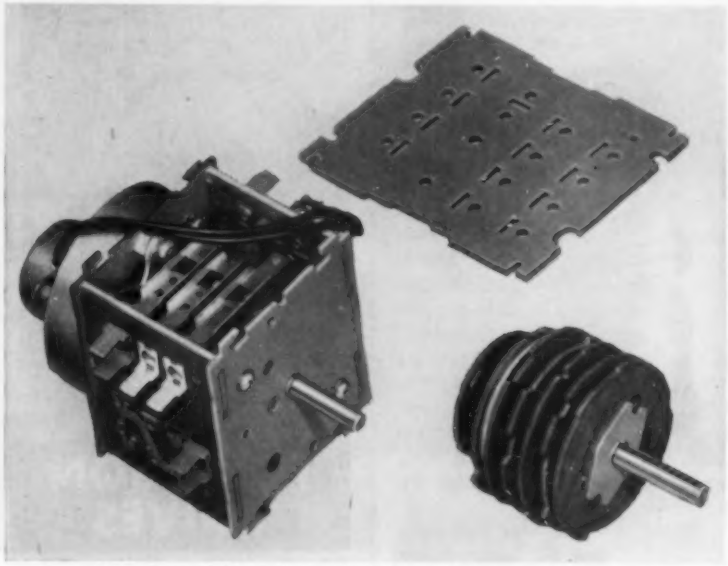
Base plate for high-voltage TV component, punched from Taylor canvas melamine laminate, has high dielectric strength and arc resistance.



Rollers for flush doors are now being made from Taylor paper base tubing with ball bearing insert . . . providing smooth, silent operation at a low cost.

NEW TAYLOR
COPPER-CLAD LAMINATES

Taylor GEC (glass-epoxy) Copper-Clad and Taylor XXXP-242 cold punching (paper-phenol) Copper-Clad. Taylor uses high purity rolled copper on base materials with outstanding electrical properties.



Interval timer switches, made by P. R. Mallory & Co. Inc., use various grades of Taylor paper base phenol laminates for cams and terminal boards. These laminates provide electrical insulation, strength, dimensional stability.

Tough specifications?
check Taylor phenol laminates

Choose from over 30 grades of Taylor phenol laminates, for the combination of electrical, physical, and machining properties you want. These rugged, versatile laminates can meet your most demanding specifications, improve end-product performance . . . and bring you major savings in material and fabrication costs.

These laminates, consisting of a paper, cotton fabric, asbestos, glass cloth or nylon base impregnated with Phenol resins, were developed to meet the need for dependable, moisture resistant insulation. They possess high dielectric and mechanical strength. Unaffected by heat or cold (except extremely high temperatures) they resist oils and most chemicals, and are especially suited to the punching and machining of accurately-sized parts. Because of their high moisture-resistance qualities, Taylor phenol laminates will not readily warp or become distorted when subjected to alternating wet and dry conditions.

You'll like the way these laminates handle in the shop . . . how they punch and stake cleanly, how they readily machine to hairline tolerances. And you'll like the way they perform in product application, how they retain their original characteristics over long periods of time and under severe operating conditions.

Taylor offers the service of its field specialists to help you choose the grade of material that matches the exact requirements of your application. Check with Taylor now. Write for the general catalog of Taylor materials. And contact your nearest Taylor sales engineer for a discussion of your particular requirements.

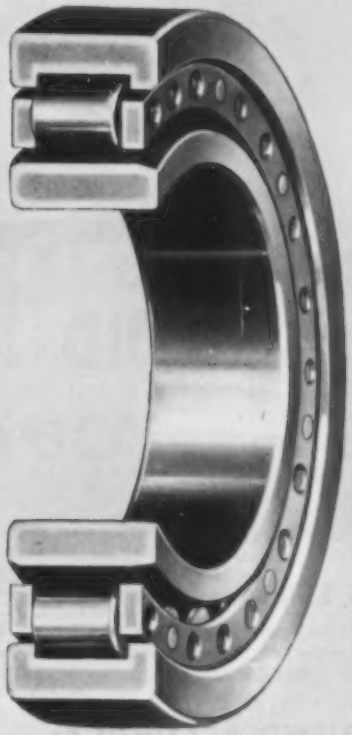
No job too little . . . or none too tough for BOWER STRAIGHT ROLLER BEARINGS

A complete line, a wide range of sizes to fit your specific needs

Square pegs weren't made for round holes. And aircraft bearings aren't built for farm equipment, either. That's why Bower designs a complete line of straight roller bearings—a line broad enough to meet any product requirement.

Jet planes break the sound barrier . . . need bearings that'll keep pace. So Bower aircraft bearings are engineered with exactness and precision to tolerances held to millionths of an inch. Bower tractor bearings, on the other hand, are built for ruggedness . . . to take heavy loads and real punishment, day after day, month after month.

Bower Roller Bearings are proved performers *in every field, for any* straight roller bearing application. From motors to earthmoving equipment, they're on the job—cutting maintenance and downtime, setting new standards of efficiency and economy. Get details on the *complete* line from a Bower engineer.



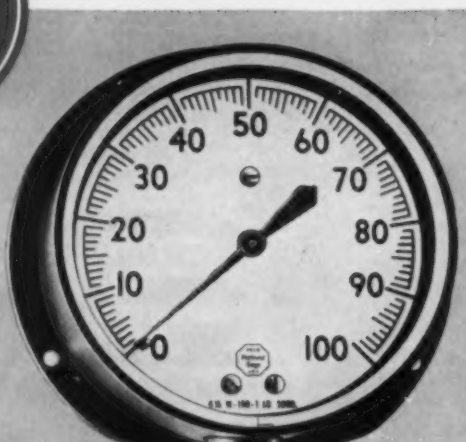
Tapered, Straight and Journal Roller Bearings for every field of transportation and industry

BOWER ROLLER BEARINGS

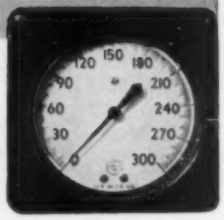
BOWER ROLLER BEARING DIVISION • FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

an ACCO product

Helicoid Gages



How HELICOID GAGES can save YOU money!



Acaloy square flush case

LONG LIFE:

HELICOID Gages are pressure instruments of extreme precision and long, trouble-free service with minimum maintenance. Have no gear teeth to wear out.

SUSTAINED ACCURACY:

HELICOID Gages have many unique and exclusive features which result in the highest degree of gage accuracy. Tubes, for instance, will withstand hundreds of thousands of pressure pulsations and will not stretch, leak or crack.

JOB-DESIGNED:

HELICOID Bourdon tubes are made from seamless tubing of alloy steel, K Monel, stainless steel or phosphor bronze. Each is designed to give best service under specific conditions. Available in complete line of cases for wall or stem mounting.

Helicoid Chemical gage

Send for catalog

ACCO

Helicoid Gage Division

AMERICAN CHAIN & CABLE

929-D Connecticut Avenue • Bridgeport 2, Connecticut

for Better Value

mitted. (1 to 60, 1 to 120 and 1 to 180)

The lead screw electro-mechanical stop is used (in a design generating large torques and inertias) to protect the assembly from the sudden shock created as either limit is reached. This is readily accomplished by the addition of a limit switch to each limit stop to cut off power just before either limit is fully reached. Associated terminals permit the switches (single-pole, double-throw, rated at 15 amp at 50 v d-c and 5 amp at 115 or 250 v a-c) to be used as normally closed or normally open units. The unit will allow from 1 to 100 turns, indicated by a double scale calibrated in number of turns for each direction of axial movement. Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y.

For more information—
Circle 104, inside back cover

Vertical Drafting Board

The board is available in two models, one with fixed board angle of 15 deg from vertical and the other adjustable through an arc of 85 deg from vertical. Both models have an up and down adjustment of 20 in., permitting draftsman to work, seated or standing, at optimum visual angle in a comfortable position on any area of the board without bending or stretching. Moving members are

(Continued on page 326)

MORE OF THE GARLOCK 2,000

Will not **CRACK** *or* **HARDEN** *at high and low temperatures.*

Garlock Silicone Rubber KLOZURE* *Oil Seals*

retain their original properties even after long exposure to temperature extremes that would quickly ruin organic rubber.

They are flexible and serviceable at temperatures as low as —90° F, and as high as 500° F . . . ideal for seals on automotive and aircraft products.

Klozure Oil Seal with Silicone Sealing Element *for high speed, high temperature applications such as transmission cases, diesel engine crankshafts, and aircraft accessory gear cases. (Model 65 illustrated.)*

Extrusions and molded parts of Silicone Rubber are only part of "The Garlock 2,000"... two thousand different styles of packings, gaskets, and seals to meet all your needs.

It's the *only* complete line . . . that's why you get unbiased recommendations from your Garlock representative. Call him today or write for Oil Seal Catalog No. 10.

THE GARLOCK PACKING COMPANY, Palmyra, New York

For Prompt Service, *contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.*

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

**Registered Trademark*

★ Model 1AM ★ Model 2AM ★ Model 4AM ★ Model 6AM ★ Model 8AM

GAST rotary vane AIR MOTORS

offer explosion-proof, variable-speed power that's surprisingly compact!

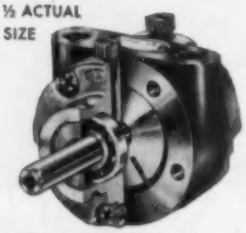
Here's the complete 5-star line of Gast rotary-vane Air Motors . . . offering ten unique advantages on products or applications located near a compressed air source:

1. Explosion-proof power in explosive or inflammable atmospheres. No sparks, no danger!
2. Low initial cost compared to other motors.
3. Variable in speed with simple valve control.
4. Can't burn out if overloaded or stalled.
5. Reversible rotation optional on 4AM and 8AM.
6. Rotor vanes take up their own wear.
7. Quickly attached to plant air lines.
8. Amazingly compact and light for h.p. delivered.
9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

As original equipment, Gast Air Motors are driving pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, thread spooling machines and many other products. Right or left rotation available. Housings available with or without foot on most models.

GAST MANUFACTURING CORP.,
P. O. Box 117-V, Benton Harbor, Mich.

MODEL 1 AM
½ ACTUAL SIZE



Note the simple principle and trouble-free construction.

PERFORMANCE TABLE				
Model No.	R.P.M.	HORSE POWER at 60 P.S.I.	at 90 P.S.I.	Wt. Lbs.
1 AM	2,000 5,000	0.11 0.21	0.13 0.30	1½
2 AM	1,000 2,000	0.22 0.40	0.35 0.57	5¼
4 AM	1,000 2,000	0.48 0.78	0.73 1.10	7½
6 AM	500 2,000	0.40 1.30	0.65 2.00	18
8 AM	500 1,500	1.00 2.30	1.45 3.80	25

For complete performance data, write for Bulletins! Specify models that interest you.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

counterbalanced without counterweights. Vertical adjustment is held by a foot-operated lock mechanism.

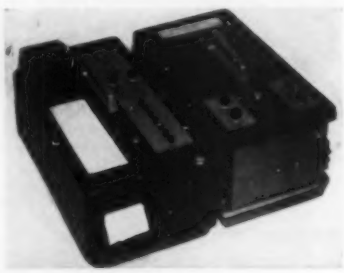
The frame of the board is of sturdy tubular steel construction with gray iron inter-connecting members. The board itself is of aluminum-lined honeycomb sandwich construction. L. A. B. Corp., 1023 Onondaga St., Skaneateles, N. Y.

For more information—
Circle 105, inside back cover

Lead Pointer Has Taper Selector

The user selects blunt, long or in-between lead tapers by rotating a taper selector, which also serves as the pencil guide. For draftsmen, engineers, artists, accountants and others who require a needle-sharp point on mechanical lead holders or lead pencils, the lead to be pointed is inserted in the pencil guide and the top rotated a few times. An abrasive liner does the work. Elward Mfg. Co., Coloma, Mich.

For more information—
Circle 106, inside back cover



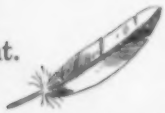
Direct-Writing Oscillograph

A two-channel, direct-writing oscillograph which provides instantaneous, permanent recordings of frequencies as high as 250 cps at 1 in. double amplitude has a companion amplifier. This equipment can record voltages from practically any source, including magnetic tape playback units, carrier amplifiers, d-c amplifiers, and telemetering discriminators. Almost any input device is suitable because of the instrument's high input impedance. In addition to frequency response flat to 250 cps, the unit has excellent

(Continued on page 330)

BIGGER THAN YOU THINK

Skinner solenoid valves are compact, tiny and lightweight.



But don't be misled — they'll easily outperform other valves that are much larger and heavier. Built to withstand high voltages and temperature extremes, Skinner valves provide leakproof, trouble-free operation through millions of cycles.

And being small, they are easily adaptable to your most compact equipment design. Call in a Skinner engineer on all your valve problems *first*. He can draw from over 100,000 variations . . . all of them *big in capacity, power and performance.*

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New Britain, Conn.

WORLD-WIDE REPRESENTATION

Ford Equips New "250"

Dayton BSI* V-Belts Used For Rugged Plunger Drive

In 1954 Engineers at Ford Motor Company, Tractor and Implement Division, were in the final stages of development on a new baler—the "250"—especially designed for the farmer with small hay acreages. Equipped with a 15 hp motor and capable of baling up to 7 tph under average conditions, it was excellent for the farmer who needed a compact, maneuverable unit and didn't want to depend on a custom operator.

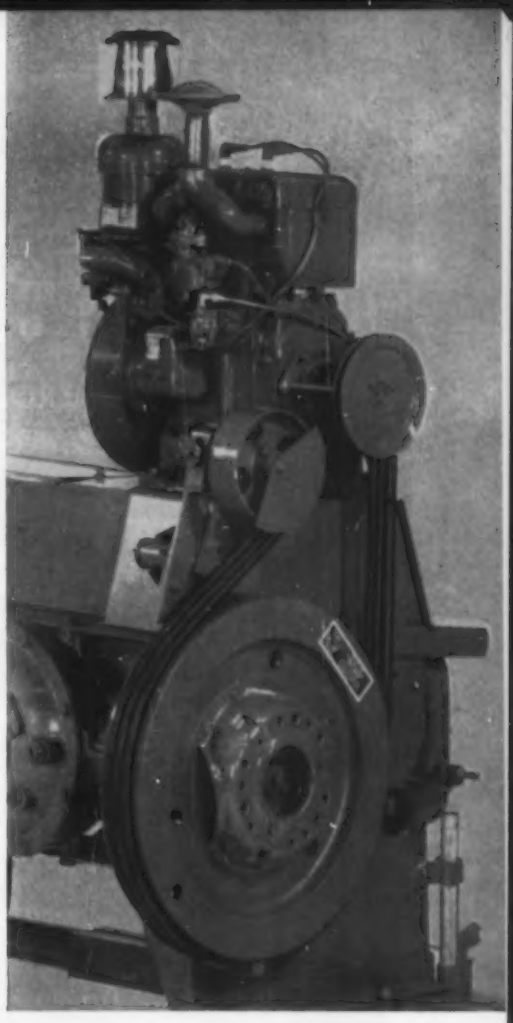
One innovation on the "250" is the use of V-Belts rather than flat belts for power transmission. Tests showed that heavy belt-stretching pulsation was set up by the baler plunger operating at 68 strokes per minute. In order to provide maximum uniform power and to forestall frequer replacement, Ford engineers decided to use V-Belts wit minimum stretch characteristics.

Dayton V-Belt Engineers were among those consulted b Ford. They were asked to recommend a low stretch be which would also take a terrific backbend.

Ford engineers had designed a spring idler to act as clutch on the V-Belt so baling could be stopped witho shutting off the engine. To accommodate the idler th V-Belts had to withstand a brutal backbend as well as po sess superior forward flexibility to get maximum "wra around the comparatively small engine sheaves.

* Back Side Idl

Three Dayton HB section BSI V-Belts combine strength and two-way flexibility in this installation on Ford's "250" Baler. They transmit a maximum, uniform flow of power from the 15 hp air-cooled engine to the flywheel. Minimum stretch characteristics built into multiple-ply V-Belt helps a spring idler keep the three belts at proper tension at all times. The idler also acts as a clutch. A fly-wheel slip clutch, one of the outstanding Ford features, protects gears, connecting rod and plunger from damage due to overloading while baling.



Baler with V-Belts

DAYTON ENGINEERS RECOMMENDED the use of three Dayton Multiple-ply BSI V-Belts to develop the same power as the original flat belt and to beat the problem of pulsating load and two-way flexibility.

Dayton Back Side Idler V-Belts (shown below) are built specifically to withstand the stresses of reverse bending. Their special construction gives them the minimum stretch characteristics needed to resist pulsation.

FORD ENGINEERS accepted the multiple-ply BSI V-Belts after the severest of laboratory and field tests. They are now in use on "250" Balers all over the country.

In every case where you need V-Belts with minimum stretch characteristics, or for any V-Belt problem, contact your Dayton Agricultural Sales Engineer . . . or write Dayton Rubber Co., Agricultural O.E.M. Division, 1500 S. Western Ave., Chicago, Ill.

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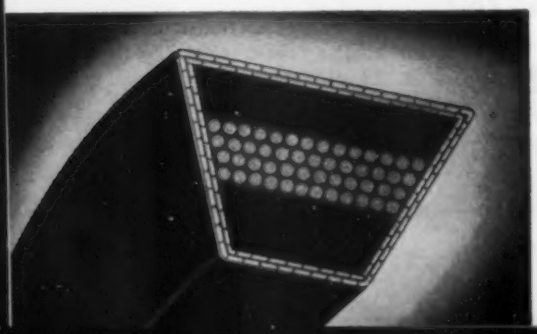


Dayton Rubber 51 YEARS OF PROGRESS

First in Agricultural V-Belts

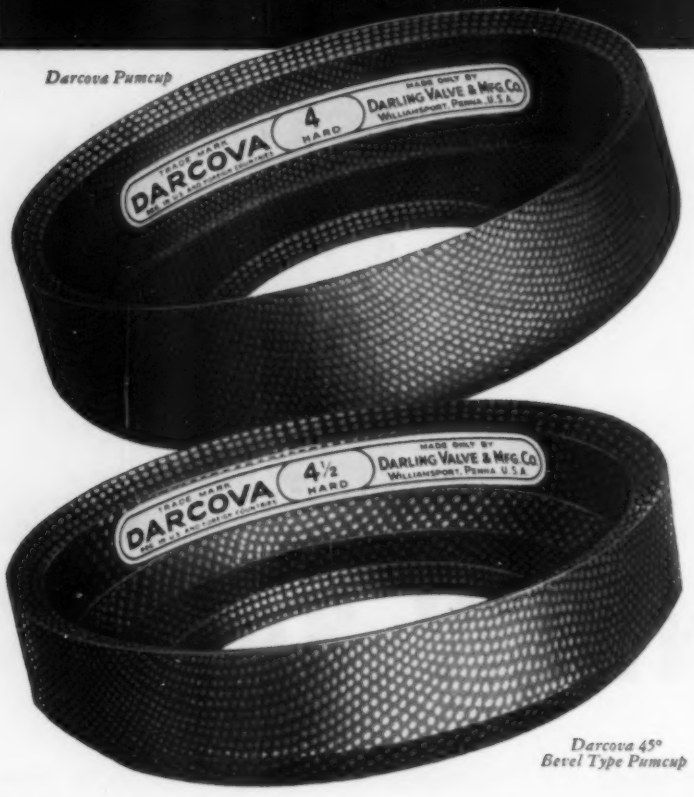
Agricultural Sales Engineers in Atlanta, Chicago, Cleveland, Dayton, Moline, New York, San Francisco and St. Louis

DARCOVA PUMCUPS

now available with

100% NYLON COMPOSITION

for HYDRAULIC CONTROLS, AIR CYLINDERS, RECIPROCATING PUMPS



Darcova Pumcup

Darcova 45° Bevel Type Pumcup

DARLING Pumcups—long noted for unequalled efficiency and life in all kinds of cylinders—are now greatly exceeding their own performance records! The new 100% Nylon Composition, available *only* in Darcova Pumcups, does it!

Nylon Pumcups are made in sizes, types and textures exactly right for your particular equipment—ready *now* to give you unprecedented piston packing performance!

Write for helpful data Bulletin No. 5503.

DARLING VALVE & MANUFACTURING CO.

Williamsport 25, Pa.

DARCOVA
THE ORIGINAL COMPOSITION CUP

TRADE MARK
PUMCUPS

square-wave and transient response. Speed-change pushbuttons select six chart speeds from 0.05 to 20 ips, and separate control knobs set the trace density for each of the two channels. Timing pulses are provided automatically at one pulse per second, or up to five pulses per second by external means. A manual event marker pushbutton can be used to mark the chart at any time. The oscillograph and the amplifier are each 9 x 10½ x 17 in., and weigh 60 and 50 lb respectively. They operate on 105 to 125 v, 60 cps a-c. Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

For more information—
Circle 107, inside back cover

Electrical Symbol Template

This template conforms to the new and revised graphical symbols prepared by the ASA. Use of these symbols is required to meet military specifications. Templates with these electrical symbols are available in three sizes, one as shown by the ASA, another one half again as large and a third that is twice as large. Keuffel & Esser, Hoboken, N. J.

For more information—
Circle 108, inside back cover

Soldering Flux Selection Kit

This general purpose flux kit contains 16 fluxes for electronic assemblies, printed circuits, tinning and hot solder dipping, stainless steel soldering and aluminum soldering. Alpha Metals, Inc., 56 Water St., Jersey City, N. J.

For more information—
Circle 109, inside back cover

Subminiature Capacitor Kit

For the convenience of engineers, a kit of high-capacitance ceramic capacitors for transistor circuits contains six each of six different capacitance values. These range in size from 13/64 in. sq. to 17/32x21/32 in. max, with thickness from 0.090 to 0.110 in. max. Mucon Corp., 9 St. Francis St., Newark 5, N. J.

For more information—
Circle 110, inside back cover

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formed parts are produced faster, at lower cost, are stronger than machined parts of the same dimensions, have higher fatigue resistance.
LET US PROVE IT ON Your PARTS
You can now have your own experimental toothed parts (including involute splines, oil grooves, etc.) ROTO-FLO formed
without buying a machine
You can prove to yourself and your company that ROTO-FLO forming will improve performance and life while lowering production costs of
your own actual parts
All you pay for is an experimental pair of racks, and special tooling if needed.
We will roll-form an experimental run of your test parts for you
Our field engineer in your area will be happy to work with you. May we ask him to supply you with complete information?
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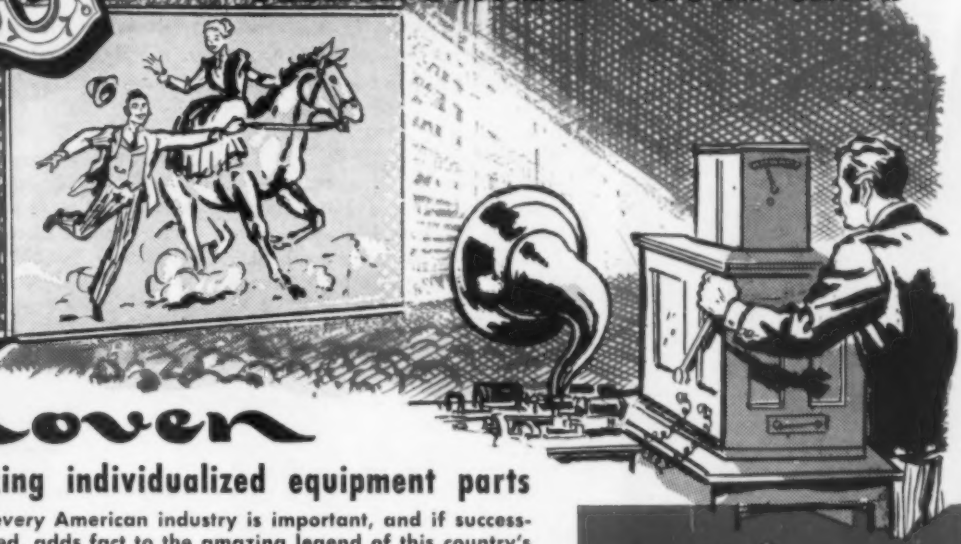
75 years ago and 12 years before Motion Pictures were invented



Koven was making individualized equipment parts

The birth of *every* American industry is important, and if successfully developed, adds fact to the amazing legend of this country's prosperity.

L. O. KOVEN & BRO., INC., having grown up with the equipment industry during the past 75 years, takes pride in having helped it to realize faster, more efficient output at lower costs. For by producing individualized equipment parts economically (often faster and more inexpensively than the manufacturers themselves) and according to the exact needs of equipment manufacturers, KOVEN has itself succeeded in becoming one of America's foremost contributors to industrial progress.

Experience of this kind can help solve your equipment production problems, too. Call or write for a consultation with a trained representative, and send for Bulletin #550. There's no obligation.

stainless steel jacketed still with downpipe

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KOVEN equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E., A.P.I. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; light and heavy fabricated piping and plate exhaust ducts. Shop and field erected storage tanks to 2 million gallons. High vacuum testing on liquid oxygen storage tanks.

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SPECIALISTS IN INTRICATE FABRICATION USING:
stainless steel • aluminum • monel • nickel
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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 364.

Bellows–Catalog 155, 20 pp. Contains information on applications, design considerations, and standards for metallic bellows. Flexonics Corp., 1351 S. Third Ave., Maywood, Ill.

Circle 111, inside back cover

Motors–Bulletin GEC 1026A, 10 pp. Contains data, ratings and prices for fhp, integral-horsepower polyphase and single phase induction motors. General Electric Co., Schenectady 5, N. Y.

Circle 112, inside back cover

Capillary Tubing–Brochure, 3 pp. Contains information on tubing for metering flow of liquids and gases. Wolverine Tube, Guardian Towers, Guardian Bldg., Detroit 26, Mich.

Circle 113, inside back cover

Hydraulic Circuit Tester–Bulletin, 2 pp. Contains specifications on portable unit. Schweder Brothers Corp., 3116 Penn Ave., Pittsburgh 1, Pa.

Circle 114, inside back cover

A-c Motor, 400 cps–Bulletin X1170, 2 pp. Contains diagrams and data. Globe Industries Inc., 1784 Stanley Ave., Dayton 4, Ohio.

Circle 115, inside back cover

Internal Gear Rotary Pumps–Catalog, 20 pp. Contains data, charts and performance figures. Wayne Pump Co., 213 Tecumseh St., Fort Wayne, Ind.

Circle 116, inside back cover

Photoelectric Controls–Bulletin PA 561, 24 pp. Contains specifications, descriptive data and operational charts on photoelectric systems for industrial control applications. Electronics Corp. of America, 1 Memorial Dr., Cambridge 42, Mass.

Circle 117, inside back cover

Paint and Protective Coatings–Bulletin 760, 28 pp. Contains data, charts and tables on surface preparation, priming, application methods and maintenance. U.S. Stoneware Co., Akron 9, Ohio.

Circle 118, inside back cover

Wire and Ribbon–Catalog, 40 pp. Contains description and price list of wire, ribbon, weld and carbostrip products. Sylvania Electric Products Inc., 12 Second Ave., Warren, Pa.

Circle 119, inside back cover

Miniature Potentiometers–Booklet, 36 pp. Contains diagrams, charts and data on precision units. Circuit Instruments Inc., 2801 Anvil St. N., P. O. Box 1438, St. Petersburg, Fla.

Circle 120, inside back cover

Gate, Globe and Angle Type Valves–Catalog F 9, 30 pp. Contains specifications, charts and diagrams on sizes ¼ to 2 in. Henry Vogt Machine Co., Louisville, Ky.

Circle 121, inside back cover

Variable Speed Control–Bulletin G561, 8 pp. Contains diagrams and data on speed adjustable drive. Reeves Pulley Co., Columbus, Ind.

Circle 122, inside back cover

Bondable Teflon and Rulon–Brochures (3). Contains information and data on plain and bondable tapes. Dixon Corp., Bristol, R. I.

Circle 123, inside back cover

Fhp Electric Motor–Brochure, 4 pp. Contains data and chart on 60 cps, 1550 rpm, fhp motor. Redmond Co., Inc., Owosso, Mich.

Circle 124, inside back cover

Adjustable Sequence Timer–Bulletin 323, 4 pp. Contains diagrams and data on multipulse repeat cycle timer. Eagle Signal Corp., Moline, Ill.

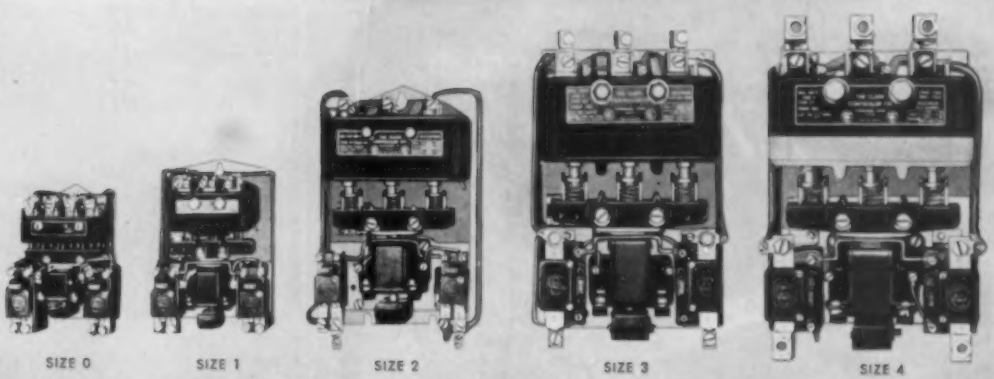
Circle 125, inside back cover

Packings–Booklet, 46 pp. Description, diagrams and charts on packings for hydraulic and pneumatic application. Trostel Packings, Ltd., Lake Geneva, Wis.

Circle 126, inside back cover

Variable Speed Motor Pulleys–Bulletin 1630 B1P, 8 pp. Contains data and charts on motor pulleys ½ through

(Continued on page 336)

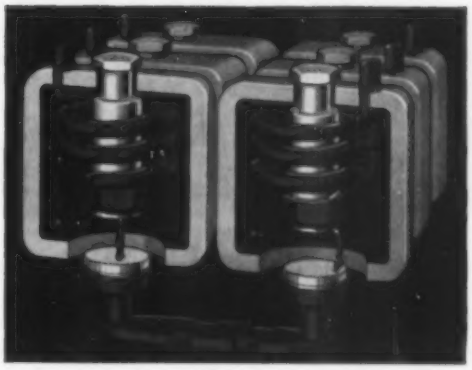


CLARK Type "CY" Starters now available in sizes

0 to 4

With the addition of the new size 4, the famous CLARK line of Type "CY" Magnetic Motor Starters now comprises the full range from 0 to 4. This means that Clark starters of the proven "CY" design incorporating vertical lift magnets are now available for more than 95% of industry's AC requirements. For installations requiring sizes 5 and larger, Clark will continue to supply dependable clapper-type starters.

Clark Type "CY" starters have many outstanding design features for more dependable operation, less maintenance and longer life. For example—rugged construction with twin-break contacts means more trouble-free service . . . contacts can be inspected without tools . . . movable and stationary contacts can be removed and replaced quickly, coils changed and the entire magnet assembly removed—all from the front—without special tools and without removing the starter from the cabinet or panel.



Revolutionary arc-quenching principle is an exclusive feature of all Clark Type "CY" starters sizes 2 and larger. It combines twin-break contacts with strong multi-turn magnetic blowouts which force the arc to rotate—alternately lengthened and confined—so that it moves continuously from a hot to a cold spot on the contact surfaces. This practically eliminates metal build-up or pitting and greatly increases contact life.

For complete information contact your nearest Clark sales office or write us direct.

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Engineered Electrical Control

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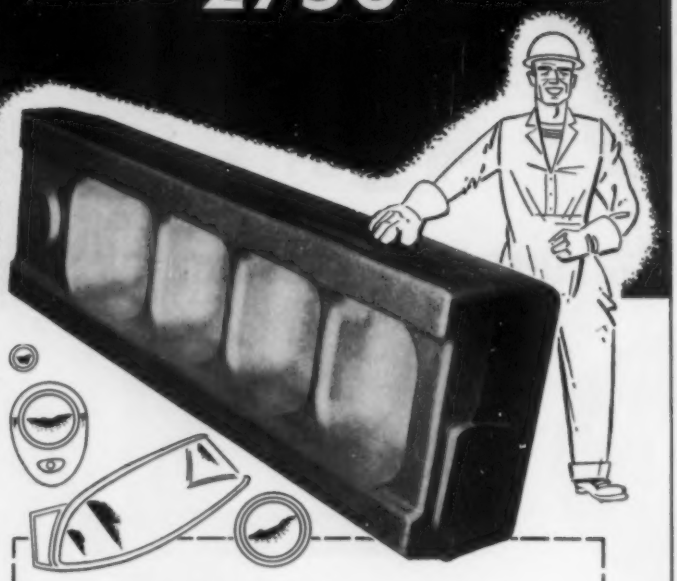
THIS PARK CLOSED-DIE FORGING WEIGHS 2750 POUNDS



. . . and over 700 of them are helping break a glass production bottleneck

Called a "table feed rack", this steel closed-die forging was specially designed for the new glass making machinery required by the automobile industry.

Park's Complete Die-Sinking Facilities provided fast, efficient service.

And Park's Advanced Heat Treating Methods and metallurgical staff assured quality control throughout the production run.

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Die Forging Specialists Since 1907

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CARBON, ALLOY AND STAINLESS STEEL CLOSED-DIE FORGINGS FROM 4 LBS. TO 5000 LBS.

¾ hp with adjustable and tilting motor bases, companion sheaves, and V-belts. Worthington Corp., Harrison, N. J.

Circle 127, inside back cover

Piston Cups–Folder, 4 pp, describes packing made of plated metal disc enclosed in molded rubber. Chicago-Atlas Mfg. Corp., 125 N. Green St., Chicago 7, Ill.

Circle 128, inside back cover

Gage Protector–Bulletin 541 G, 2 pp describes device designed to protect sensitive pressure instruments. Industrial Engineering Corp., 525 E. Woodbine, Louisville, Ky.

Circle 129, inside back cover

Silicone Rubber–Brochure, 4 pp, gives availability, distributors and price list of silicone and allied products. Connecticut Hard Rubber Co., 407 E. St., New Haven 9, Conn.

Circle 130, inside back cover

Vibration Meter–Brochure, 3 pp, describes operation and specifications. Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle 131, inside back cover

Pump Motor–Brochure, 3 pp, has diagrams, specification and performance charts of hydraulic pump motor. Gerotor May Corp., Box 86, Baltimore 3, Md.

Circle 132, inside back cover

Properties of Non-Woven Dacron Felts–Bulletin D 78, 12 pp. Contains data and charts on tensile strength, chemical and heat resistance, resilience and absorption capacity. E. I. DuPont De Nemours & Co., Textile Fibers Dept., Wilmington 98, Del.

Circle 133, inside back cover

Copper-Clad Laminated Board–Brochure, 16 pp. Contains data on the problems of printed circuitry, selection of laminates, plated circuits, plating through holes, flush circuit production and circuit fabricating. Formica Corp., 4614 Spring Grove Ave., Cincinnati 32, Ohio.

Circle 134, inside back cover

Plastic Rod and Tubes–Catalog, 24 pp. Contains sizes and prices of rod and tube stock make of methyl methacrylate, Teflon, cast acrylic,

(Continued on page 341)

Here is an entirely new series of clutches combining, in a single compact unit, all of the PROVED advantages of MAXITORQ Floating Disc Clutch design with an exceptionally simple, powerful, and dependable electro-magnetic actuating mechanism.

As will be seen from the illustration, the new clutches use standard proved MAXITORQ Disc-Pacs, quickly and easily replaced. The electro-magnetic unit is enclosed in a stationary housing, permitting direct wiring connection. When energized, the magnetic coil acts through an armature plate and sleeve to exert pressure on the clutch discs. Pressure, however, is maintained entirely by the magnetic flux, without mechanical contact between moving and stationary parts.

This unique design permits instant, positive engagement or disengagement, with the additional possibility of precisely controlling torque for a gradual pick-up or release of load. In addition to meeting standard clutch and brake installation requirements, MAXITORQ Electric Clutches open up new possibilities in application to fully automated equipment and for remote control.

Standard sizes, both single and double types, for wet or dry operation, are available with up to 788 ft. lbs. torque, and operate on 110V-AC rectified to 90V-DC.

Complete details sent on request. Write Dept. PE-10.

- **PROVED** performance.
- **COMPACT** design.
- **FLOATING** neutral . . . no drag.
- **POSITIVE** engagement.
- **STATIONARY** coil . . . no brushes.
- **NO ADJUSTMENT.**
- **WET OR DRY** operation.
- **FULL** power transmission.
- **FULL** range of sizes, types.

THE CARLYLE JOHNSON MACHINE COMPANY

MANCHESTER, CONNECTICUT

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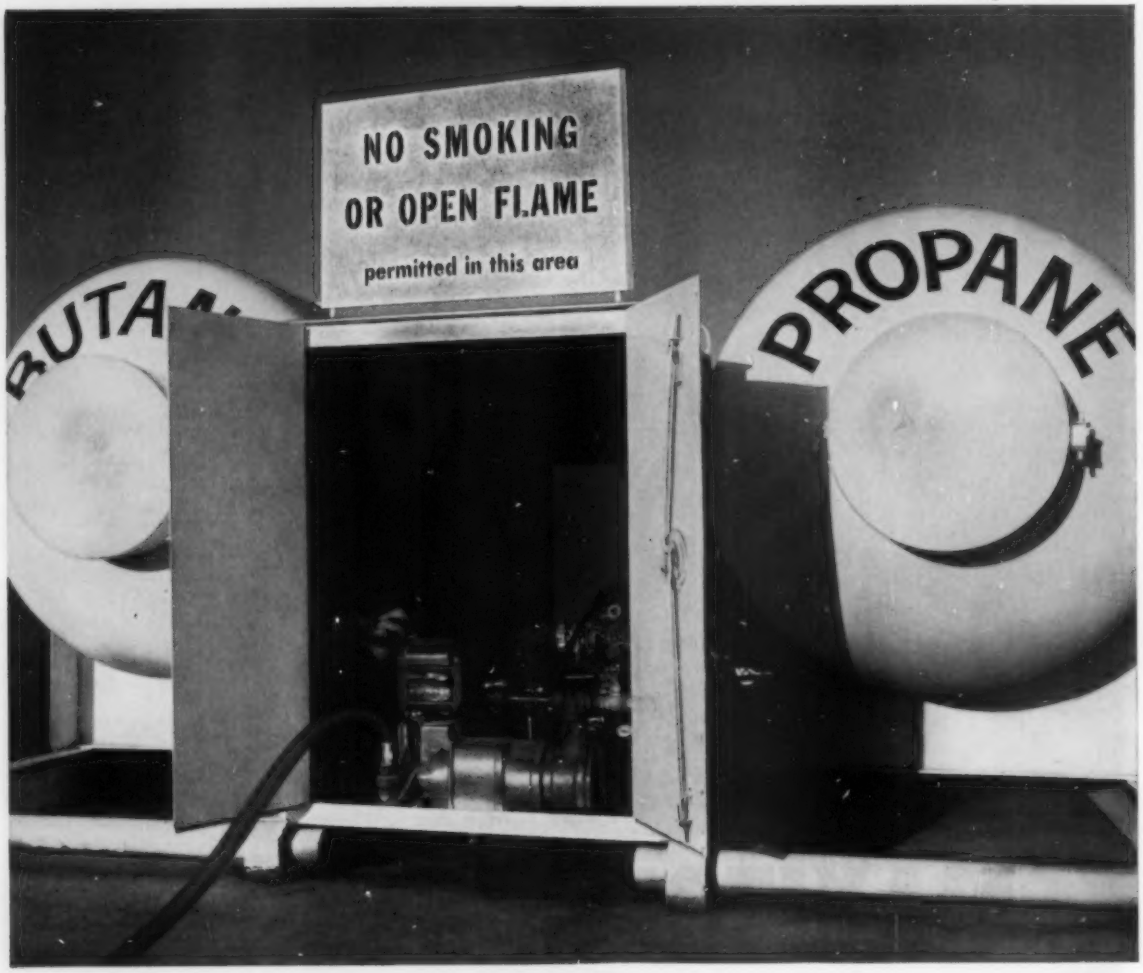

LELAND explosion-proof MOTORS SAFELY PUMP LPG

Leland's superior explosion-proof motors, designed for pumping volatile materials, function under a wide variety of explosive conditions—like the LPG installation illustrated.

Here a custom-engineered Leland motor, assembled integrally with an LPG pump manufactured by Corken's Inc., Oklahoma City, provides additional space besides appearance and performance advantages. Anhydrous ammonia, another newcomer, is similarly handled in farm fertilizing programs, with Leland motors driving pumps produced by many U. S. Manufacturers.

For over thirty years, explosion-proof Leland gasoline pump motors have outsold all others combined. Now, as the American economy demands additional volatiles, for use in industry, on the farm, or in the home—look to Leland for explosion-proof motor drives. You'll find reliability and performance in a complete line of explosion-proof motors, standard and special constructions, listed by Underwriters' Laboratories for Class 1, Group D, and Class II, Groups F & G service; drip-proof and totally enclosed types, too.

For additional information on ratings from ¼ to 5 horsepower, soon to 20 HP, write, wire or phone us, today.

Another AMF Product
LELAND MOTORS

THE LELAND ELECTRIC COMPANY
Dayton 1, Ohio
Division of AMERICAN MACHINE & FOUNDRY COMPANY

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VISTEX* with TEFLON** Gasketing Material

Another first for American! The exceptional thermal and chemical properties of Teflon are combined with low, cold flow characteristics to give you a gasketing material never before available.

With thermal stability up to 420F. Vistex with Teflon eliminates undesirable lateral plastic flow with excellent stability to corrosive gases, liquids and virtually all chemicals at low and high temperatures.

Vistex with Teflon, with tensile strength of 5,000 psi, has very high tear value, will not ravel or fray, has very good cutting properties. Seals with minimum pressure on polished or irregular surfaces.

American's engineering and research staff is prepared to supply you with complete data and product recommendations. Write today on your company letterhead.

*VISTEX—Reg. Trade-mark of American Felt Company
**TEFLON—Reg. Trade-mark of DU PONT for its Tetrafluoroethylene resin.

American Felt Company
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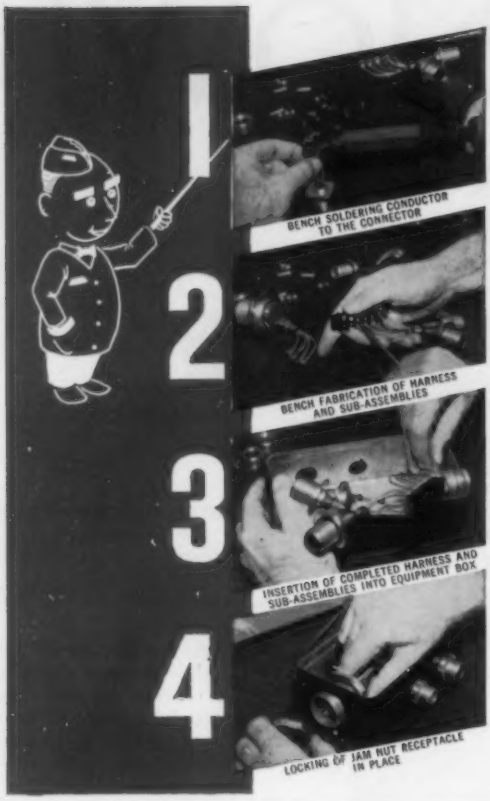
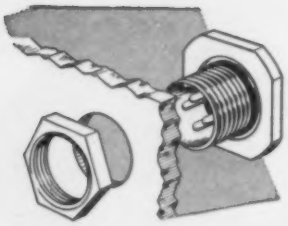

1
2
3
4
BENCH SOLDERING CONDUCTOR TO THE CONNECTOR
BENCH FABRICATION OF HARNESS AND SUB-ASSEMBLIES
INSERTION OF COMPLETED HARNESS AND SUB-ASSEMBLIES INTO EQUIPMENT BOX
LOCKING OF JAM NUT RECEPTACLE IN PLACE



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Easy to install, to service, to replace

Jam nut receptacles offer such positive savings in assembly time that it will pay you to check into their application on your product. These receptacles permit bench wiring of harness and sub-assemblies prior to final installation with proven savings in assembly labor.

Just consider these design advantages—only one mounting hole required per receptacle—no extra gasket required—no user problem of sealing around screw holes—no extra hardware necessary such as screws, washers or nuts.

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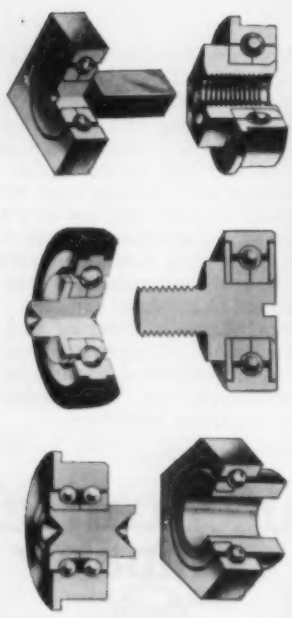

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Kilian Steel Ball Corporation 100 Wellington St., Hartford, Conn.

vinyl, polyethylene, cellulose acetate and polystyrene. Friedrich & Dimmock, Inc., Lincoln Ave., Millville, N. J.

Circle 135, inside back cover

Applications of Control Fundamentals to Combustion–Booklet, 12 pp. Contains a review of automatic means for sensing heat requirements to assure correct proportioning of fuel and air, describing key system components. Cleveland Fuel Equipment Co., 1111 Brookpark Rd., Cleveland 9, Ohio.

Circle 136, inside back cover

Pneumatic Die Cushions–Brochure, 4 pp. Contains diagrams, table and data. Dayton Rogers Mfg. Co., Minneapolis 7, Minn.

Circle 137, inside back cover

Mica Insulation–Booklet, 10 pp. Describes development and gives information about types for molding, segment, heater and flexible plates; tapes, flexible combinations, tubes and capacitor grade. Mica Insulator Co., P. O. Box 1076, Schenectady 1, N. Y.

Circle 138, inside back cover

Armored Multitube System–Bulletin 356, 12 pp. Information on multitube and methods of installation. Copper and polyethylene tubes are illustrated. Crescent Insulated Wire & Cable Co., Trenton, N. J.

Circle 139, inside back cover

Electronic Component Data Service–Brochure, 7 pp. Describes service for electronic engineers which uses a machine card system. Data, Inc., 67 Lawrence Ave., West Orange, N. J.

Circle 140, inside back cover

Effect of Diameter on Rubber Covered Squeeze Rolls–Report No. 10, 2 pp. Discusses and illustrates with graphs, deflection of typical rubber rolls under various loads. Rodney Hunt Machine Co., Industrial Roll Div., Orange, Mass.

Circle 141, inside back cover

Gears–Catalog 101, 8 pp. Contains description and pictures of spur, helical, bevel, miter, internal and worm gears. Adams Co., Dubuque, Iowa.

Circle 142, inside back cover

Transformers–Catalog, 26 pp. Contains specifications, pictures and prices of open frame, cased, channel frame

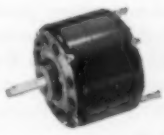
(Continued on page 345)

ENGINEERING KNOW HOW!

General Industries
FRACTIONAL HP. MOTORS
1/40 HP. to 1/1100 HP.

Engineering Know How . . . means efficient performance and longer life . . . a prime factor in every GI FRACTIONAL HP MOTOR.

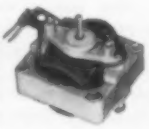
■ *Engineering Know How* is just one of the reasons why so many original equipment manufacturers have come to rely on GI. They know that a GI 1/40 hp to 1/1100 hp motor will "hit the specs" every time; there's no "almost" about a GI fractional hp motor. Manufacturers like General Industries' free design consultation service and right-on-the-dot deliveries, too. When you have a fractional hp requirement, you'll find that your best bet is to . . . specify GI!



MODEL B
4-pole, 4-coil shaded pole AC Induction Type

MODEL A
2-pole, shaded pole AC Induction Type

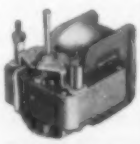
MODEL C
2-pole, shaded pole AC Induction Type



MODEL E
4-pole, shaded pole AC Induction Type

MODEL O
2-pole Capacitor Reversible Type AC only (for 6, 12, or 24 volts)

MODEL D
4-pole, 4-coil shaded pole AC Induction Type



MODEL F
2-pole, shaded pole AC Induction Type

Write for Complete Specifications and Quantity - Price Quotations!

THE GENERAL INDUSTRIES CO.
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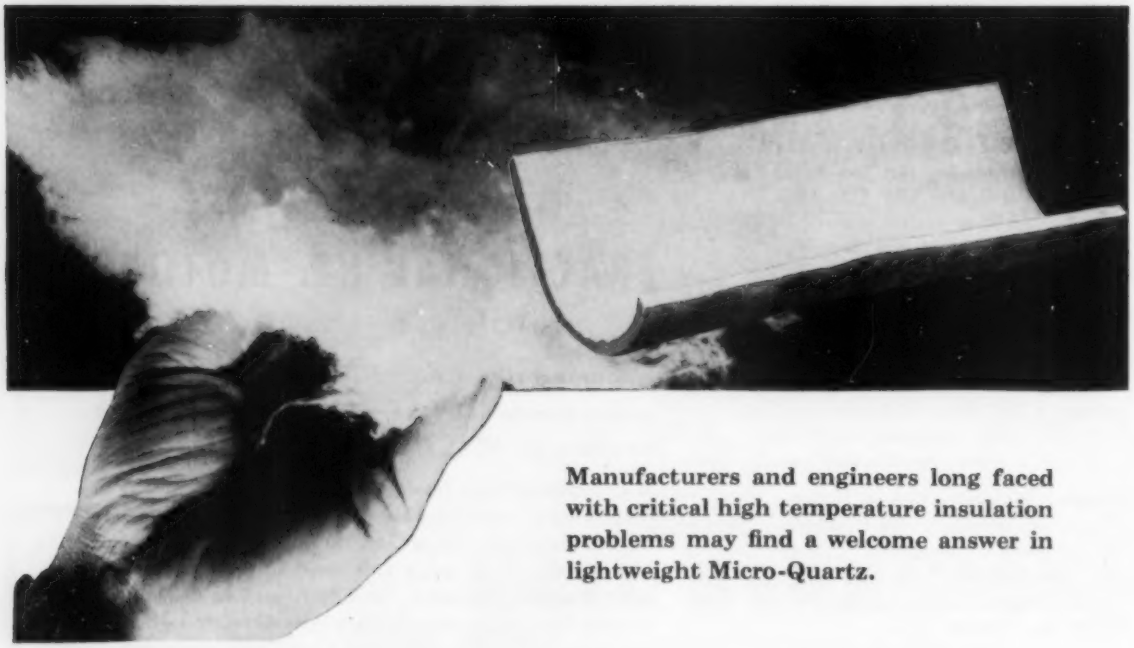
L·O·F Glass Fibers Company Introduces

MICRO-QUARTZ—The new insulation for the 2000°-2500° Temperature Range!



Manufacturers and engineers long faced with critical high temperature insulation problems may find a welcome answer in lightweight Micro-Quartz.

L·O·F Glass Fibers Company announces Micro-Quartz—a remarkable, new insulation for temperatures ranging, under many conditions, up to 2500°!

Micro-Quartz is available in felted form and in bulk. It is light in weight and composed of 98% pure quartz. It is resilient, exceptionally efficient, and resistant to vibration and air flow. Because it has no organic binder, its performance, stability, and thermal conductivity are those of the quartz fibers themselves.

The range of uses to which Micro-Quartz can be put is very broad, with possible applications in all industries doing work in the high-temperature field. It may be the answer to high temperature problems involving low heat capacity and high thermal diffusivity, frequent- or rapid-heating cycles, and problems of weight, space limitations, and vibration.

Micro-Quartz fibers are available in paper form. Can be impregnated or coated for electrical applications.

Requests on your business letterhead for more information, and a Micro-Quartz sample, will receive prompt attention. Write: L·O·F Glass Fibers Company, Dept. 4-106, 1810 Madison Ave., Toledo 1, Ohio.

PRODUCT DATA ON STANDARD MICRO-QUARTZ SHEETS*

Average Fiber Diameter—0.75 microns or 0.00003 inches

Density—Standard nominal density is 3 lbs./cu. ft.

Weight—0.047 lbs. per sq. ft.—0.005 lbs.

Thickness of sheet—Standard nominal thickness is 3/16 inches

Width of sheet—34 inches

Length of sheet—71 inches

*Other thicknesses and densities are available. Sheets can be fabricated to fit your application.

L·O·F GLASS FIBERS Micro-Quartz HIGH TEMPERATURE INSULATION

L·O·F GLASS FIBERS COMPANY

TOLEDO 1, OHIO

Makers of glass fibers by the exclusive "Electronic-Extrusion" process

Schrader 3-WAY PILOT VALVES, which respond to the out-of-phase cam-operated valves, automatically actuate unscrambling actions on conveyor. Some other Schrader Air Products involved in this operation are indicated in red (Numbers 1 through 5).

How Schrader Air Products automatically

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Arranging bars of hardened paraffin from a disorganized pile to orderly groups of five, ready for packaging, is a cinch at one New York plant. Schrader Air Products do the job fast and accurately, unattended. Air-activated "fingers" of metal do the trick, as fast as the bars descend the incline.

Every day, new ways are discovered for performing operations automatically with Schrader Air Products. Schrader's line of industrial products includes hundreds of units which can be arranged in limitless combinations for thousands of different jobs. And air always brings to any job its basic economy, safety and efficiency.

Do *you* know the Schrader story in relation to *your* plant's needs? Learn it now, by asking for Schrader engineering assistance in planning for most efficient use of air in your plant. Outline your problems for us and we can help you select the products best suited to your applications. Or, send for the latest informative booklets which show Schrader Air Products that will help you increase production—economically.

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INSIDE INFO FROM HOLO-KROME

THE SECRET'S IN THE SOCKET!

Since 1932, H-K has completely forged socket screws for greater strength where needed. Originally developed by Holo-Krome, cold-forming maintains metal fibers intact for greater strength. No drilling or broaching to weaken an H-K socket wall. You get tougher screws when they're H-K's!

Holo-Krome sockets completely forged!

Compare These Other H-K Features!

SCIENTIFICALLY DESIGNED SOCKETS . . . depth carefully proportioned to give greatest head and socket strength, firmest key grip.

SHARP HEX CORNERS . . . carefully formed socket corners resist internal reaming.

UNTAPERED WALLS . . . for better key fit, longer key and socket life, even tighter wrenching.

For the finest in Socket Screw products . . . for revolutionary SAME-DAY SERVICE, the name to remember is Holo-Krome!

LOOK INSIDE A HOLO-KROME SOCKET!

Send in the coupon below and we'll send you FREE an H-K Socket Cap Screw (we've omitted heat treating to let you get a better look at the mirror finish and sharp hex corners under the usual black finish). Look it over carefully, and see for yourself what a real difference H-K quality and skill can make!

Please send me FREE a Holo-Krome Socket Screw for my inspection.

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THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN.

Sold only through authorized Holo-Krome distributors.

and end bell cased transformers. Nothelfer Winding Lab., Inc., 111 Albermarle Ave., Trenton, N. J.
Circle 143, inside back cover

Motor Pulleys–Catalog V563, 8 pp. Contains diagrams and data on units from ¼ to 1½ hp and in speed ratios up to 2.75:1. Reeves Pulley Co., 1225 Seventh St., Columbus, Ind.
Circle 144, inside back cover

Tubular Products, Fittings and Flanges–Brochure TDC186, 3 pp. Provides specifications and applications ASTM, AAR. Babcock & Wilcox Co., Beaver Falls, Pa.
Circle 145, inside back cover

Aluminum Data–Bulletin, 8 pp. Guide to selection of flat rolled aluminum, characteristics of rods and bars, and specifications for building panels. Joseph T. Ryerson & Son, Inc., Box 8000-A, Chicago 80, Ill.
Circle 146, inside back cover

Diaphragm Valves, Metering and Proportioning Pumps–Catalog 9G-56, 16 pp. Specifications, tables and information. Hills-McCanna Co., 2430 W. Nelson St., Chicago, Ill.
Circle 147, inside back cover

Hydraulic Straight Thread Fittings–Catalog ST-56, 24 pp. Data, diagrams and tables of metal ring seal fittings, and seal fitting with and without O-rings. L and L Mfg. Co., 8088 E. Nine Mile Rd., Van Dyke, Mich.
Circle 148, inside back cover

Leaded Steel for Forged and Rolled Rings–Bulletin, 8 pp. Contains data and test results. Alco Products, Inc., P. O. Box 1065, Schenectady, N. Y.
Circle 149, inside back cover

Hand Rubber–Brochure, 4 pp. Contains data, characteristics charts, and molding tolerances of hard and resin rubbers. Stokes Molded Products, Trenton, N. J.
Circle 150, inside back cover

Fluid Drive–Bulletin 9819, 8 pp. Diagrams, data and charts on adjustable speed fluid drives. American Blower Corp., Detroit 32, Mich.
Circle 151, inside back cover

Clutches and Brakes–Bulletin 500A, 36 pp. Contains applications, tables and design data on clutches, brakes,

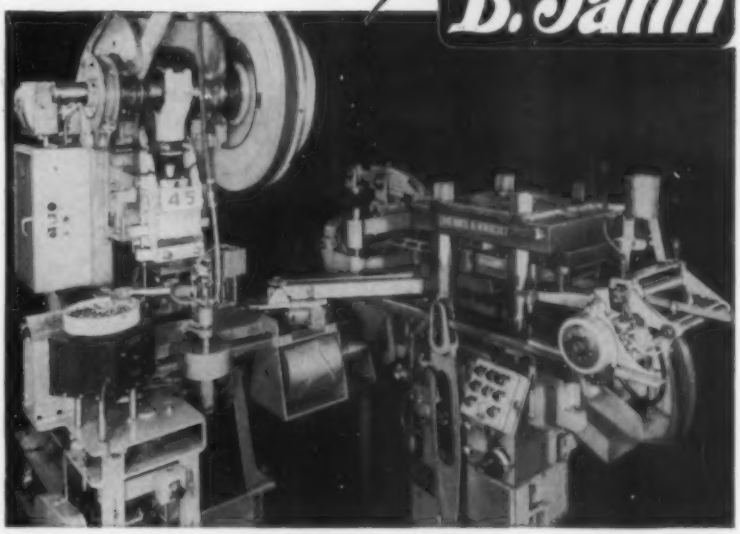
(Continued on page 348)

2 PRESSES . . . 1 PROGRESSIVE DIE . . . 1 STIPPLING DIE . . . ENGINEERING INGENUITY . . . SPECIAL MACHINERY . . . SPECIAL ELECTRICAL COMPONENTS . . .

produce

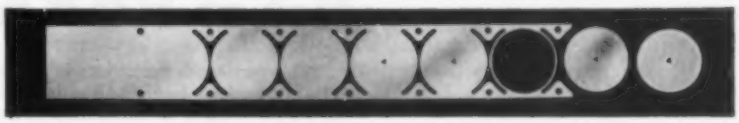
AUTOMATION

by **B. Jahn**



Here's true automation — 100% automatic production, 100% B. Jahn built, that transforms .025" aluminum into precise meter components 3⅝" in diameter — each with 720 teeth .009" deep — without human hands, human error!

Equipped with B. Jahn progressive die, one 60 ton press was linked by a chain drive to a 45 ton press incorporating a stippling die.



Progressive die, ground all over to guarantee greater accuracy, longer service, less downtime, pierces and blanks intricate discs.

Conveyor system feeds disc into air-operated vacuum arm that positions piece in B. Jahn stippling die. Another arm removes stippled piece and places it on stacking unit.

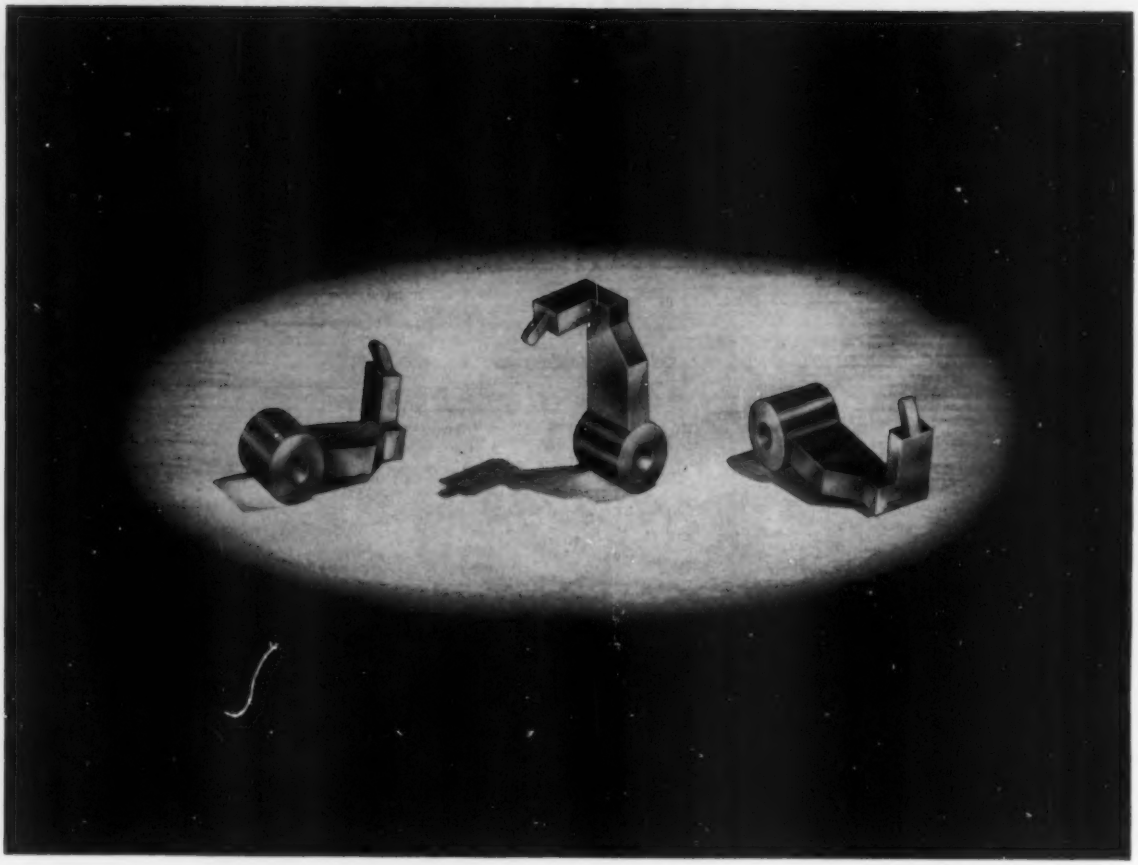
Completed discs, at the rate of 30 per minute, are automatically stacked and spaced on spindle.

Here's true AUTOMATION, true production economy!

Get Full Details On This Astounding "No Hands . . . No Delay . . . No Error" Automation Application — Send Today for the Big New B. Jahn Brochure.

B. Jahn

THE B. JAHN MANUFACTURING COMPANY, NEW BRITAIN, CONNECTICUT



Impossible in Powdered Metal? Not at PARKER

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This part—with projections in several planes, not to mention an I.D.-O.D. section—looked like an impossible job for powdered metal. Yet Parker made it in **one press operation**—complete—to close tolerances and tight "specs"—at relatively **low cost.**

This unusual piece points up the advantages offered by Parker powdered metal processing. Tough cost problems of conventional casting and machining methods often can be solved. Tensile strength, ductility and impact resistance can be closely controlled to meet rigid specifications. Powdered metal constituents can be precisely and uniformly blended for a wide range of requirements.

Parker's experience and facilities in producing a wide variety of powdered metal parts have saved money—and solved problems—for many users. Your problem may be one that Parker can solve in like manner. Just call the nearest Parker sales engineer listed at the left.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pa.

PARKER

POWDERED METAL PARTS
ALUMINUM and ZINC
die castings

TEN AJAX DIHEDRAL COUPLINGS deliver 25,000 H.P. on new U E & F mill at Weirton

Close-up shows two of five pairs of Ajax Dihedral Spindle Couplings driving 23" and 56" x 52" 4 high 5 stand tandem cold mill built by United Engineering & Foundry Co. for Weirton Steel Co., a Division of National Steel Corporation.

▶ The critical eyes of steel men are focused on the design, performance and output of every new mill and all its components. This new 4 high, 5 stand tandem cold mill, designed for speeds up to 7200 fpm, was built by United Engineering and Foundry Co. for the Weirton Steel Co., a Division of National Steel Corporation.

It is turning out sheet of high quality finish and maintaining close gauge tolerance.

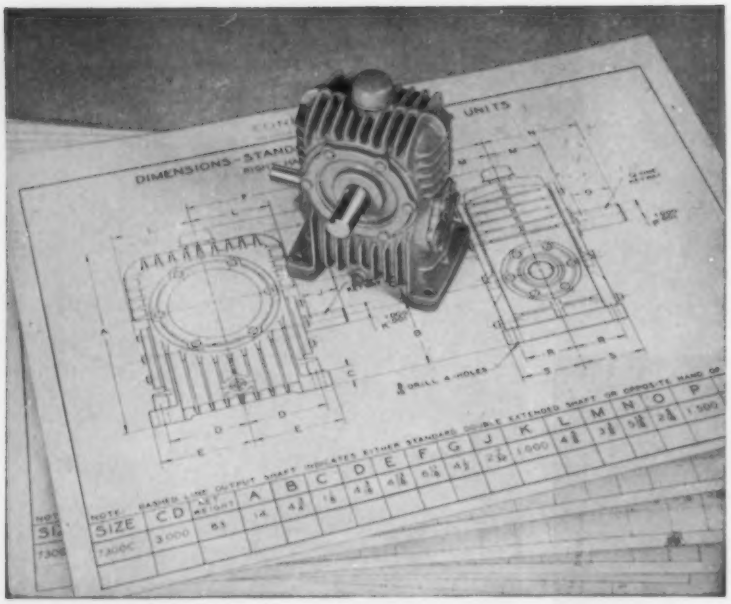
Power is transmitted from drive stands to rolls by 10 Ajax Dihedral Spindle Couplings handling 2500 H. P. each. The uniform angular velocity of Ajax Dihedral Spindle Couplings is an important factor in producing smooth finish, uniform thickness and long roll life.

Ajax Dihedral Spindle Couplings are in operation in America's foremost steel mills. They have been proved and approved by every test of time and service. Whether you are designing, specifying, building, using or modernizing mills, it will pay you to get the facts on Ajax Dihedral Spindle Couplings.

Write for Bulletin No. 58.

AJAX

AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, N. Y.



DIMENSIONS ONLY TELL HALF THE STORY...

. . . about worm gear speed reducers. You've got to compare size with load capacity for the whole picture. Inside a Cone-Drive speed reducer you'll find the double-enveloping worm gear design that makes it the most efficient right-angle speed reducer available.

Take the standard 3" center distance unit above for example. Here are its Class I Service Ratings with a 5:1 reduction:

Worm RPM	100	200	300	580	720	870	1150	1750
Mech. HP	1.24	2.21	3.08	4.89	5.61	6.34	7.41	9.04
Thermal HP	1.24	2.21	3.08	4.20	4.62	5.10	6.00	7.80
Output Torque (inch-lbs.)	3340	3010	2830	2405	2250	2150	1940	1575

That's a lot of capacity for a unit that occupies less floor space than this magazine page. But it's typical of Cone-Drive speed reducers and gearsets. Complete details on this model in Bulletin 600-C. Other units to 800 HP and ratios to 4900:1.

CONE-DRIVE GEARS
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
Division Michigan Tool Company
7171 E. McNichols Road • Detroit 12, Michigan

couplings, power take-offs, rotorseals, quick release valves and high-speed controls. Fawick Corp., 9919 Clinton Rd., Cleveland 11, Ohio.

Circle 152, inside back cover

Rolled Steel Pattern—Brochure, 15 pp. Contains pictures and information on design pattern. Sharon Steel Corp., Sharon, Pa.

Circle 153, inside back cover

Self-Locking Bolts—Brochure, 6 pp. Contains diagrams, information and charts on self-locking and sealing screws and bolts. Buffalo Bolt Co., N. Tonawanda, N. Y.

Circle 154, inside back cover

Excitation System—Booklet 5.08, 8 pp. Description and diagrams of alternator regulation and control. Electric Regulator Corp., Pearl St., Norwalk, Conn.

Circle 155, inside back cover

Torque Converter—Bulletin 508, 4 pp. Describes and illustrates single stage torque converter. Twin Disc Clutch Co., Rockford, Ill.

Circle 156, inside back cover

Fhp Motor Selector—Chart. Gives characteristics and performance ranges of a variety of motor types. Howard Industries, Inc., 1760 State St., Racine, Wis.

Circle 157, inside back cover

High-Temperature Alloys—Booklet, 10 pp. Describes wrought, nickel-base, aluminum and titanium-bearing alloy. Haynes Stellite Co., 30-20 Thomson Ave., Long Island City 1, N. Y.

Circle 158, inside back cover

Pressure, Temperature and Level Control Valves—Bulletin 56C, 8 pp. Describes reducing valves, pump governors, relief valves, temperature regulators, feedwater regulators, float valves, damper regulators and combustion control valves. Atlas Valve Co., 280 S. St., Newark 5, N. J.

Circle 159, inside back cover

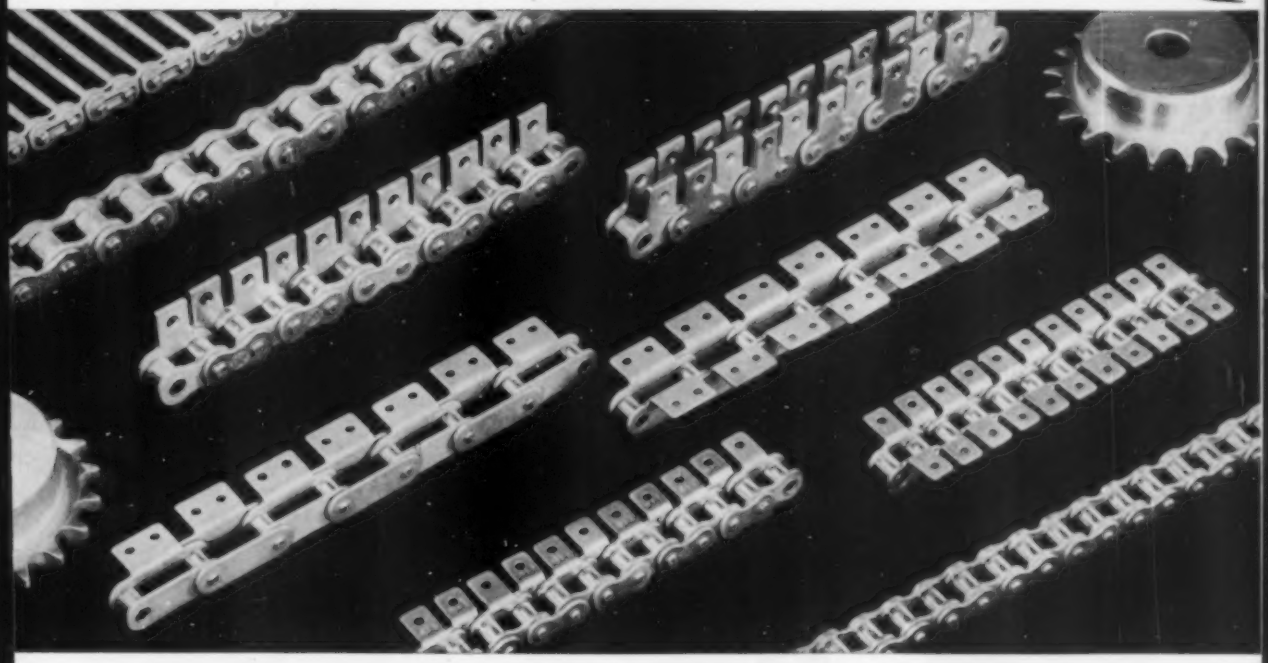
Geared and Shaded Pole Motors—Catalog, 12 pp. Contains diagrams, data and characteristics charts. Loyd Scruggs Co., Festus, Mo.

Circle 160, inside back cover

Electronic Data—Handbook, 69 pp. Contains formulas and data. Included are formulas for current analysis, transmission line calculation, determination

(Continued on page 353)

it's NEW! it's Revolutionary it's Electrolized!



ATLAS ROLLER CHAIN

CORROSIVE RESISTANT...COSTS 40% LESS
COMPARATIVE TESTS PROVE IT WEARS 100% LONGER

From coast to coast manufacturers, engineers and transmission drive specialists are acclaiming this as the most revolutionary development in the roller chain field. It meets the most exacting requirements of the chemical, food, beverage and other industries where corrosion resistance is a factor. Yet it has been tested and proved to outlast, outrun and outwear other chains even though it costs far less.

HIGHER TENSILE STRENGTH—has same tensile strength as alloy steel chain . . . much higher than bronze or stainless steel chain.

LONGER WEARING—actual wear-drive tests prove it lasts as much as 100% longer than alloy steel chain.

STAINPROOF, CORROSIVE RESISTANT—corrosion resistance is greatly increased in Electrolized Chain and compares favorably with any other corrosion resistant chain now on the market.

LOWER PRICE—of Atlas Chain makes it as much as 40% less in cost than any other corrosion resistant chain now on the market.

Here's the chain that makes it possible for you to re-evaluate the specifications of your transmission drives. From the standpoint of cost, efficiency and longer wear it allows you to specify corrosion resistant chain on drives previously ruled out due to high cost and short chain life.

You owe it to your plant to contact your nearest Atlas distributor to get the complete story on Atlas Electrolized Roller Chain and Sprockets. He can help you attain a new standard of efficiency on your transmission drives.

ATLAS CHAIN AND MANUFACTURING CO.
West Pittston, Penna.

GET THIS DATA ON ELECTROLIZED CHAIN

This free brochure tells you in brief question and answer form all about Electrolized Chain. Write for your copy today.

"Bet a fish it's got **SKF** bearings!"

Don't take that bet, bird – unless you have fish to burn!

SKF is the company that sells *all four* basic types of bearings. And that means you'll find our bearings in more applications ... in more places in the world ... than any other bearings. In everything from roller skates to roaring jets, these bearings literally make the world go round. *Plus-quality* **SKF** Bearings are serving your industry, your family and you right now! 7720

SKF

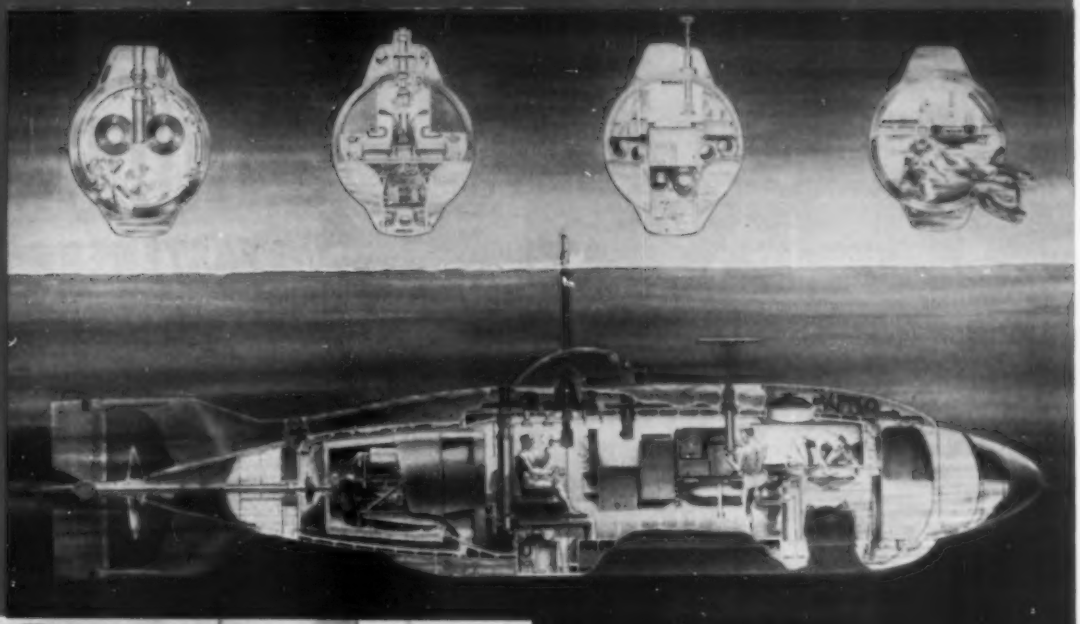
SKF—EVERY TYPE—EVERY USE

- *Ball Bearings*
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings* ("Tyson")

*Reg. U.S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

the COVERED Apex universal joint assemblies on the USS X-1...



are PROTECTED against salt water corrosion

The aircraft type controls on the Navy's new 4-man midget submarine required universal joints that would operate efficiently, under diving pressures, in stagnant sea water.

Salt water corrosion, always a troublesome factor in marine design, posed no problem here. Fairchild Engine Division, builders of the USS X-1, selected Apex covered universal joint assemblies for the diving planes and rudder drives. Salt water corrosion is sealed OUT—clean, sustained lubrication is sealed IN.

This exclusive Apex design feature has proved invaluable on other applications, in a variety of industries, where Apex universal joints operate in wet or dry, corrosive or abrasive conditions, and in extremes of temperatures.

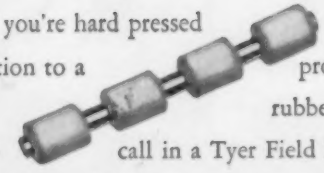
There are still other exclusive Apex design features which have greatly improved standard universal joint applications and have opened new applications never before feasible. If your design problem involves universal joints or universal joint assemblies, you should have the complete story. Write, on your company letterhead please, for our Catalog 27.

APEX

industrial universal joints—3/8" to 4" diameters

THE APEX MACHINE & TOOL COMPANY
1039 S. Patterson Blvd. • Dayton 2, Ohio

If you're hard pressed for the solution to a problem in molded rubber, your best bet is to call in a Tyer Field Engineer. He will show you how Tyer's extensive technical knowledge and specialized experience have been put to work for other companies, and how they can help you, too.



Our 100th TYER 1955 Anniversary

Tyer *Rubber Company*

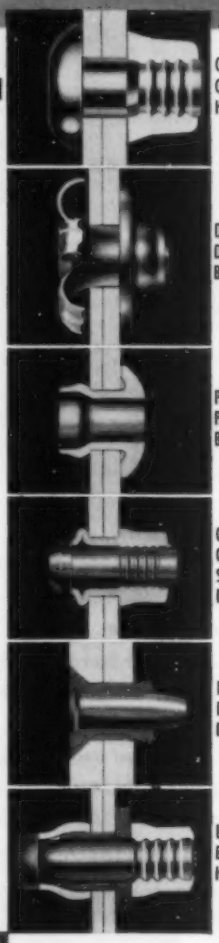
ANDOVER, MASSACHUSETTS, U. S. A.

TYER RUBBER COMPANY PE 10
Industrial Division, Andover 95, Massachusetts
Gentlemen:
☐ Please send me the new *Tyer Rubber Engineering Brochure* including technical specifications and relative properties of natural and synthetic rubbers.
☐ Please have Tyer field engineer call on_____ (date)
No obligation, of course.

NAME_____
FIRM_____
STREET_____
CITY_____ ZONE_____ STATE_____

- FASTER, EASIER INSTALLATION
- GREATER STRENGTH
- UNIFORM TENSION
- MAXIMUM SHEAR STRENGTH
- PRECISION FIT
- LOWER INSTALLED COST

Huck permanent fasteners are available in many types, shapes and sizes, from 3/32" to 1/2" diameter, to meet the requirements of all types of manufacturers from railroad cars, trailers, buses, ships, blowers, appliances, to farm equipment and prefab buildings. These and many other users specify Huck fasteners for reasons of economy, speed of application, strength and dependability. You too, may find the answer to faster, better, cost-cutting assembly by investigating Huck's advantages. Write for literature, or ask for a Huck Sales Engineer who will be glad to explain the advantages of Huck Fasteners in your product. No obligation.



CL— Commercial Huckbolt

DR— Daisy Blind Rivet

PT— Pull-Thru Blind Rivet

OS— Oversize Structural Blind Rivet

DEUTSCH— Drive-Pin Blind Rivet

BL— Blind Huckbolt

HUCK MANUFACTURING COMPANY
2480 Bellevue Avenue • Detroit 7, Michigan

of vacuum tube characteristics, resonance and meter calculations. Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill.

Circle 161, inside back cover

Flexible Couplings—Bulletin 3 pp. Contains description of couplings with torque capacities from 1/80 to 3500 hp. Lord Mfg. Co., 1635 W. 12 St., Erie, Pa.

Circle 162, inside back cover

Lubricating Equipment—Catalog 10, 32 pp. Contains data and diagrams on oil cups, oiling systems, dispensers, valves, gages and chain oilers. Oil-Rite Corp., 2318 Waldo Blvd., Manitowoc, Wis.

Circle 163, inside back cover

Hydraulic Control Valves and Pumps—Catalog, 72 pp. Contains diagrams, data and price list. Gresen Mfg. Co., 628 Colfax Ave. N., Minneapolis 11, Minn.

Circle 164, inside back cover

Phenolic and Melamine Molding Compounds—Catalog, 41 pp. Contains information and price list of moldings for industrial use. Fiberite Corp. 512 W. 4 St., Winona, Minn.

Circle 165, inside back cover

Welded Steel Tubing—Chart or Booklet. Contains tolerances and size ranges for square, rectangular and round carbon and stainless steel welded mechanical tubing. Steel and Tubes Div., Republic Steel, 224 E. 131 St., Cleveland 8, Ohio.

Circle 166, inside back cover

Self-Locking Screws, Bolts and Inserts—Catalog 11B, 12 pp. Describes with diagrams and charts self-locking fasteners. Nylok Corp., E 14 St., Elmira Heights, N. Y.

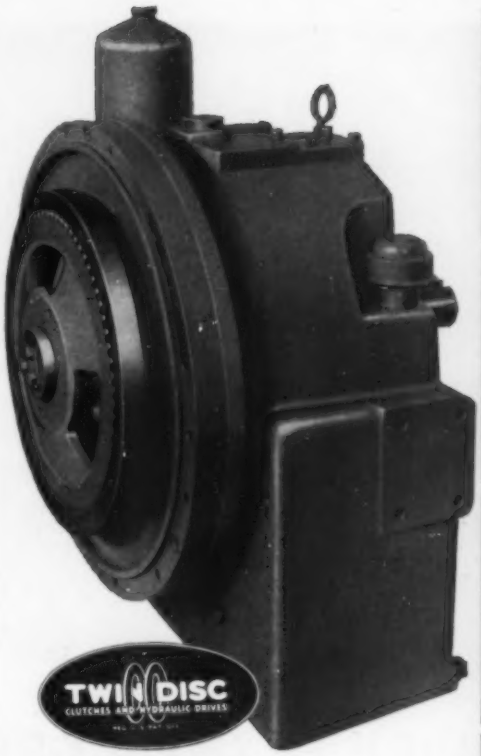
Circle 167, inside back cover

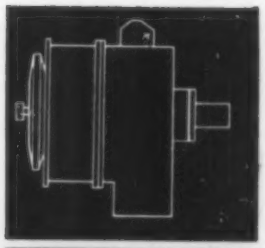
Proximity Transducer Systems—Bulletin CPP356, 6 pp. Information on transducer systems for use in counting and automation. Electro Products Lab., 4501 N. Ravenswood Ave., Chicago 40, Ill.

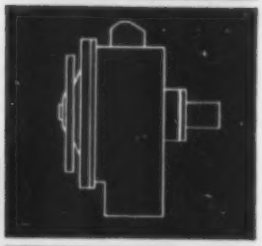
Circle 168, inside back cover

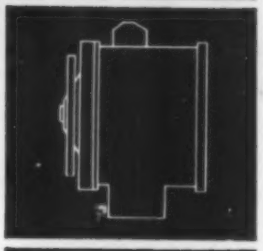
Super-High Strength Steels for Aircraft Applications—Booklet, 29 pp. Contains description of methods and compositions which increase the strength levels of the basic 4340

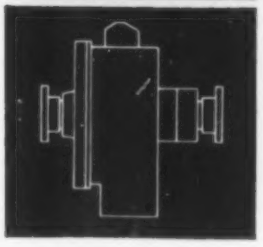
(Continued on page 356)











announces new

SINGLE-STAGE

Torque Converters

Here's another good answer to the power transmission problems involved in today's heavy-duty machinery—the all new Twin Disc *Single-Stage* Torque Converter.

The new single-stage torque converter is currently available in the 1500 Series, which is applicable to engines producing from 30 hp at 1150 rpm to 207 hp at 2500 rpm. Four models provide various input and output combinations.

Already time-proved by extensive field tests, this single-stage torque converter is ideal for use in shovels, hoists, draglines, front-end loaders . . . in all types of construction, mining, logging and oil field equipment requiring smooth, efficient, dependable torque multiplication.

This new Twin Disc Torque Converter will cut operating costs . . . boost profits . . . handle the toughest jobs with ease. The converter's smooth flow of power eliminates sudden load shocks between engine and driven equipment . . . cushions out harmful vibrations.

In designing new models, or modifying existing ones, consult Twin Disc for *unbiased recommendations* on *either* new single-stage *or* long-established three-stage torque converters.

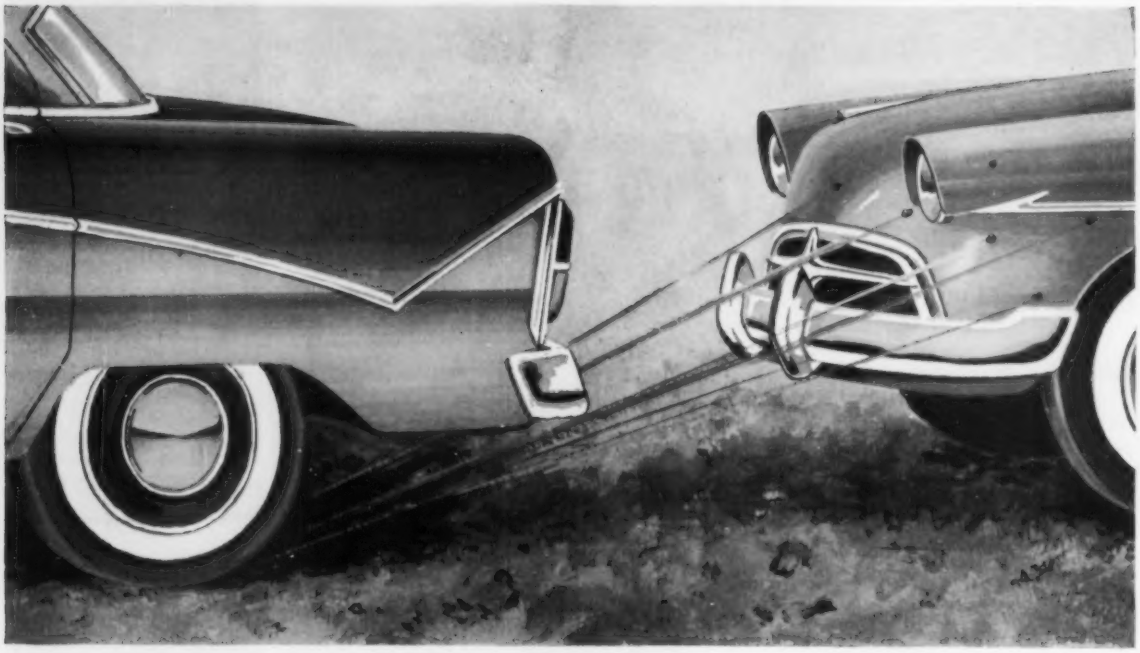
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC

Torque Converters

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

Branches or Sales Engineering Offices: Cleveland • Dallas • Detroit • Los Angeles • Newark • New Orleans • Tulsa



NEW HIGH IN IMPACT-RESISTANCE

under organic finishes:

Pennsalt FOSBOND zinc phosphate coatings

Rough treatment, chipping impacts, severe weathering and corrosion—those old paint-damaging standbys—are no longer bogeys to the organic finishing operation. Pennsalt's know-how in metal surface preparation has produced a series of FOSBOND® zinc phosphate coatings that protect steel surfaces against these abuses better than other methods thus far developed.

If your problem is impact . . . corrosion . . . other chemical and physical conditions that wreak havoc on paint adhesion—there's a Fosbond cycle to meet it, at low cost and without any change in your present equipment.

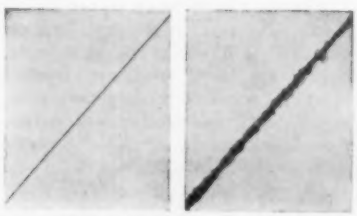
Let the man who knows look at your phosphating problem! He's from Pennsalt, where the greatest store of metalworking chemical knowledge is ready to help you. Call him or write Metal Processing Dept. 368, Pennsylvania Salt Manufacturing Company. East: Three Penn Center Plaza, Philadelphia 2, Pa.; West: 2020 Milvia Street, Berkeley 4, Calif.

In Canada: Pennsalt Chemicals of Canada, Hamilton, Ontario.

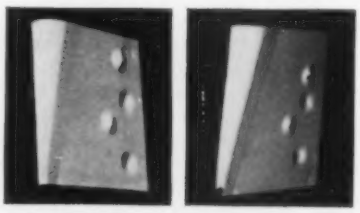
Pennsalt Chemicals

Metal Cleaners • Phosphate Coatings • Cold-Working Lubricants

CHIP-RESISTANCE. Finishes on Fosbonded panels resist twice the weight of impact as do finishes applied over conventional zinc-phosphate coatings.

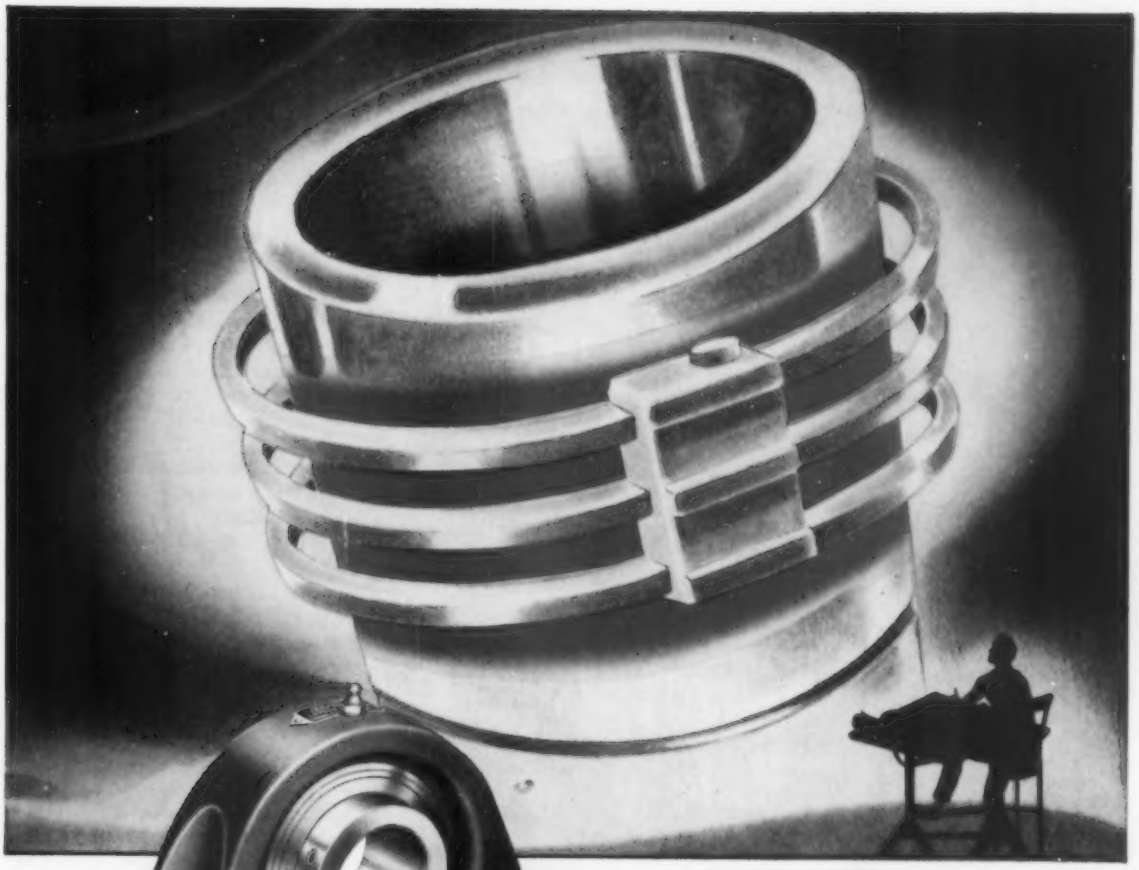


SALT-SPRAY TEST. No creep of corrosion on Fosbonded panel after 300-hour exposure, while conventional zinc phosphate allows 1/16" undermining of paint film.



IMPACT TEST. No paint fractures on impact and bending of Fosbonded panel (left), while paint on panel with conventional coating fractures from same treatment.

A BETTER START FOR YOUR FINISH



THIS ONE FEATURE *ALONE* MAKES SEALMASTER OUTSTANDING

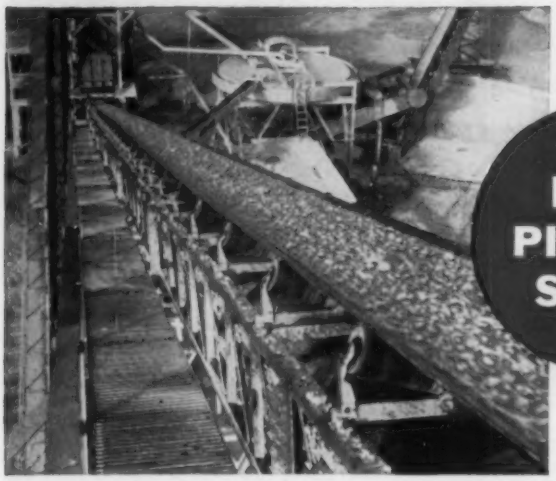
ZONE HARDENING

SEALMASTER Ball Bearing Units provide a patented exclusive feature, **Zone Hardening**, which assures a positive race to shaft lock. **Zone Hardening** is a completely automatic heat treating process by which the inner race ring of SEALMASTER Ball Bearing Units is hardened through the ball path and adjacent section only. The extended portion of the inner race is left in its original metallurgically soft, tough state. Hardened set-screws are mounted through this soft portion of the race, permitting race-to-shaft locking with increased holding power and greater resistance to vibration and shock.

You'll want full information on the advantages of this and other SEALMASTER features—such as Self-Alignment, Locking Pin & Perimeter Dimple, Labyrinth Seal, Floating Ball Retainer, etc. Write for Bulletin 454 today.

SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO., 9 RIDGEWAY AVE., AURORA, ILLINOIS

Thermoid Conveyor Belts



In designing conveyors for quarry work, Blanchard Machinery Corporation has entirely different conveyor belt requirements than the designers of the Flaherty "Spread-Master". Yet both specify Thermoid. They know Thermoid **personalized engineering service** assures the right belt for longest wear and trouble-free performance.

Whether your product plans call for a Conveyor Belt, V-Belts, Hose, Brake Blocks, Clutch Facings or other rubber or friction components, find out how Thermoid multi-plant facilities, **personalized engineering,** and 75 years' experience, can help you.

Thermoid Company
Trenton, New Jersey

Thermoid

nickel-chromium-molybdenum alloy steel. International Nickel Co., Inc., New York 5, N. Y.
Circle 169, inside back cover

Glossary of Plastics Terms—Brochure, 4 pp. Lists 85 definitions. Richardson Co., 2769 Lake St., Melrose Park, Ill.
Circle 170, inside back cover

Seamless Welding Fittings and Flanges—Brochure FB-502, 5 pp. Describes carbon, alloy and stainless steel fittings and forged steel flanges. Babcock & Wilcox Co., Beaver Falls, Pa.
Circle 171, inside back cover

Electric Motors—Chart aids in selection of fhp motors. Howard Industries Inc., Racine, Wis.
Circle 172, inside back cover

Remote Reading Gages—Catalog 291, 8 pp. Contains data on gages in four pressure groups from under 900 psi to over 1500 psi. Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.
Circle 173, inside back cover

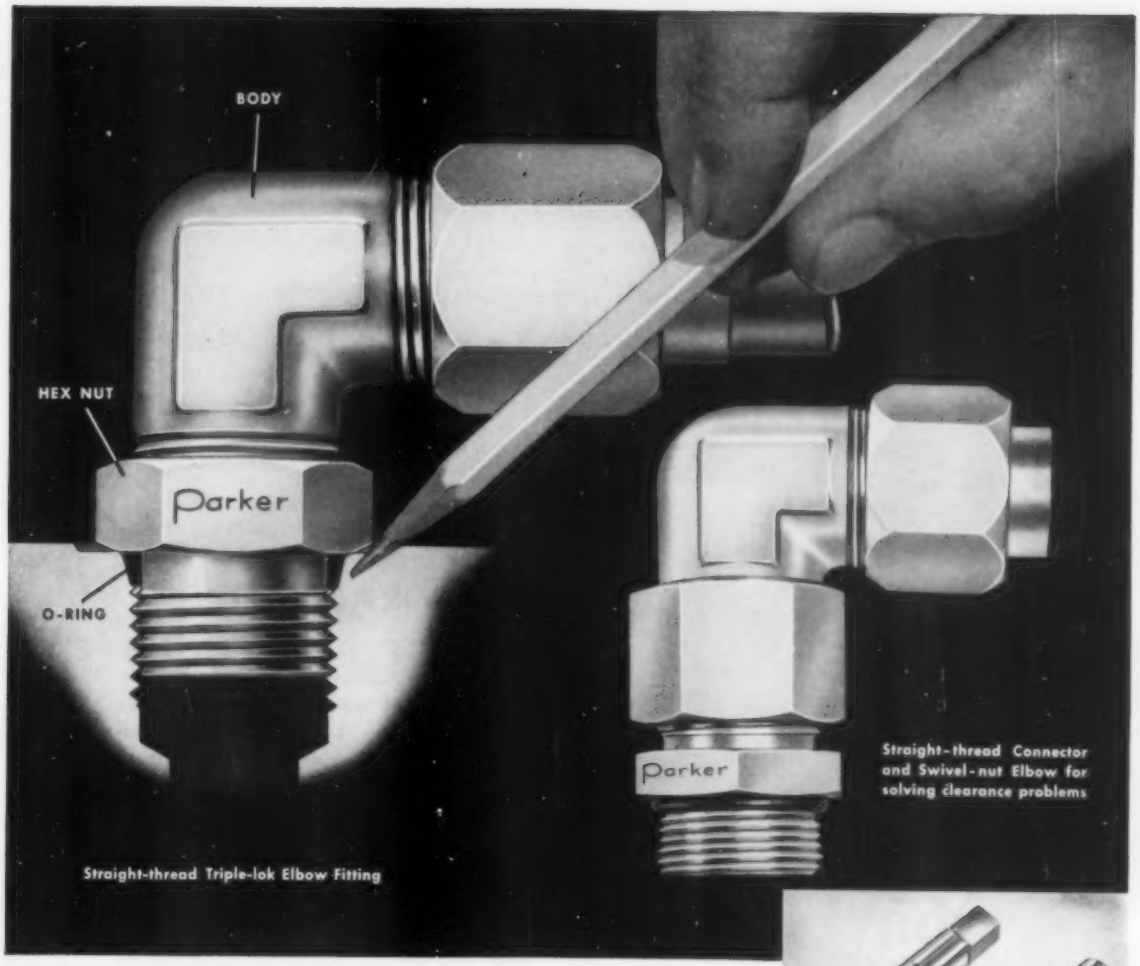
Control Systems—Catalog SF9901, 16 pp. Describes the various systems, equipment and components manufactured by Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y.
Circle 174, inside back cover

Motors and Generators—Catalog, 72 pp. Includes data, tables and charts on squirrel cage horizontal, multi-speed, wound rotor, vertical solid shaft, and special purpose and brake motors. Marble-Card Electric Corp., Gladstone, Mich.
Circle 175, inside back cover

Thermistors—Manual TH13A, 53 pp. Contains charts and data on thermally sensitive resistors for automatic detection, measurement and control of physical energy. General Electric Co., Detroit 32, Mich.
Circle 176, inside back cover

Comparative Coatings—Chart, illustrates various resistances obtainable in comparing coatings made on resin bases. J. Landau Co., Carlstadt, N. J.
Circle 177, inside back cover

Pearlitic Malleable Iron—Booklet, 24 pp. Contains information on the strength and machinability in highly
(Continued on page 360)



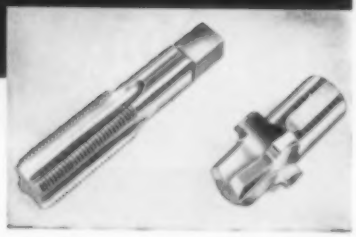
New Parker *straight*-thread fittings solve your leakage problems

Now you can forget about high-pressure hydraulic problems resulting from tapered pipe threads. Forget about leakage . . . about the danger of cracking or distorting valve bodies by over-tightening the fittings . . . about damaged threads from over-tightening to obtain proper positioning. Forget about messy pipe "dope".

You can eliminate all of these problems by using new Parker *straight*-thread fittings with positive O-ring seals. (See illustration above.)

Parker *straight*-thread fittings are now being supplied in response to the growing demand for this new type of leakproof, trouble-free connection. They are shorter and have smaller hexes than the AN fitting for the old AND 10050 boss. *Straight* threads are available on *Triple-lok* (the industrial standard flare tube fitting) and on *Ferulok* (flareless fitting for heavy steel tubing).

This is another example of Parker's pioneering leadership in the field of hydraulic fittings. Mail the coupon today for complete information.



Precision thread-tapping and counterboring tools for making accurate *straight*-thread boss (to receive these new Parker *straight*-thread fittings) are now available with machining drawings from Parker.

TUBE AND HOSE FITTINGS DIVISION
Section 412-U

The Parker Appliance Company
17325 Euclid Avenue
Cleveland 12, Ohio
Send Catalog 4301.

Name_____

Company_____

Address_____

City_____ State_____

Parker

Hydraulic and fluid system components

New equipment, expanded departments, added technical personnel and increased productivity all help to make Long your ideal "production partner."

But you'll discover Long's real plus factors in our management-engineering team. Its talent for creating high quality products with economical design and volume manufacturing advantages is your biggest profit potential.

LONG-BUILT TRACTOR RADIATORS GIVE TOP PERFORMANCE

Tractor engines need specialized cooling to do the best possible job. Leading tractor manufacturers specify Long-built radiators because they are rugged and dependable; *because they are engineered for the best performance under the severest field requirements.*

Since 1903 Long has been engineering and building high quality heat exchangers for industry. Whatever the type of fuel used, your engine cooling can be improved. Ask us for help on *your* problem.

LONG B-W BORG-WARNER

LONG®

LONG MANUFACTURING DIVISION, BORG-WARNER CORPORATION
12501 DeQuindre Street, Detroit 12, Michigan
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THE STANDARD OF QUALITY AND PERFORMANCE SINCE 1903

LEADERS IN INDUSTRIAL SAFETY: U. S. STEEL

At U. S. Steel, a thorough going safety program is *vital* to efficient production. As a part of this over-all program, fire-resistant Pydraul is used for hydraulically operated equipment located in potential danger areas.

A Tested Combination: Pydraul Hydraulic Fluid in Askania Regulators

Where it's a matter of hydraulic control of pressure, flow and ratio at U. S. Steel, you'll often find dependable Askania Regulators on the job—in blast furnaces, coke ovens, open hearths and soaking pits. Near these intense heat sources, U. S. Steel uses Pydraul to operate this and other hydraulic equipment. Here's why:

Pydraul is fire resistant . . . the only fire-resistant hydraulic fluid listed with Underwriters' Laboratories.

Pydraul gives you more than safety. You can be sure of long equipment life with low maintenance . . . because Pydraul lubricates like a premium petroleum oil. You'll save money on fluid consumption, too! Pydraul is reclaimable —you can return spillage to the system, use it again and again.

If you have any hydraulic equipment that must operate near hot metal, electrical contacts, open flame or other heat sources, you might be taking a needless risk. Your Monsanto representative will show you how easy and economical it is to convert to a fire-safe Pydraul system.

Write for a Pydraul F-9 booklet. Organic Chemicals Division, MONSANTO CHEMICAL COMPANY, Dept. PYD-4, St. Louis 1, Mo.

Pydraul F-9—first and only hydraulic fluid listed by Underwriters' Laboratories.

"In respect to fire hazard, Pydraul F-9 is rated by Underwriters' Laboratories, Inc., 2 to 3 in a class much less flammable than paraffin (petroleum) oil, according to a schedule in which Ether is rated 100; Gasoline 90—100; Alcohol (ethyl) 60—70; Kerosene 30—40; Paraffin Oil, 10—20." *Pydraul: Reg. U. S. Pat. Off.*

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WHERE CREATIVE CHEMISTRY WORKS WONDERS FOR YOU

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ENGINEERED CONTACTS, SLIP RINGS & ALLOYS

Supplied To Your Specifications By . . .

NEY

Ney offers wide experience in the development of sliding contacts, slip rings and assemblies, commutator segments and assemblies, brush and brush holder assemblies, and precious metal resistance wire. Call or write the Ney Engineering Department for consultation on any problem involving the use of precious metals to improve your products.

THE J. M. NEY COMPANY, P.O. BOX 990, DEPT. J, HARTFORD 1, CONN.

Specialists in Precious Metal Metallurgy since 1812

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here's the **FREE** answer to better low-cost power transmission...

for Chain Drive users

Write today for the first really Engineered approach to the problem of supplying custom sprockets "off-the-shelf" . . . .

your shaft size + bushing + sprocket = Grip-Master stock delivery

Low installation cost . . . Low maintenance cost . . . All sizes in steel . . . No extra machining needed!

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POWER TRANSMISSION ROLLER CHAINS AND SPROCKETS

REPRESENTATIVES IN ALL PRINCIPAL CITIES

CULLMAN WHEEL COMPANY 1334 ALTGELD STREET, CHICAGO 14, ILLINOIS

Catalogs and Bulletins . . . . . continued

stressed parts used in both mobile and stationary mechanisms. Albion Malleable Iron Co., Albion, Mich.

Circle 178, inside back cover

Plate Form and Multiplane Mountings—Bulletin, 16 pp. Contains data, tables and design details. Lord Mfg. Co., 1635 W Twelfth St., Erie, Pa.

Circle 179, inside back cover

Precision Bearings—Catalog 52A, 128 pp. Contains information and tables on bearings as well as formulas for many purposes. McGill Mfg. Co. Inc., Valparaiso, Ind.

Circle 180, inside back cover

Motors—Bulletin 51B7225D, 5 pp. Contains data and charts on totally-enclosed, fan-cooled motors in NEMA rerated ratings of ½ to 30 hp and in non-rerated ratings of ½ to 100 hp. Allis-Chalmers Mfg. Co., 1002 S. 70th St., Milwaukee, Wis.

Circle 181, inside back cover

Supercharger—Brochure, 4 pp. Contains diagrams, data and charts. Miehle-Dexter Supercharger, 100 4 St., Racine, Wis.

Circle 182, inside back cover

Aluminum Extrusions, Components and Assemblies—Brochure, 8 pp. Contains pictures and information. Cupples Products Corp., 2650 S. Hanley Rd., Maplewood, St. Louis 17, Mo.

Circle 183, inside back cover

Explosion-Proof Motor—Bulletin 51B-7286G, 5 pp. Contains data and charts on motors in NEMA rerated ratings of ½ to 30 hp and in non-rerated ratings of ½ to 100 hp. Allis-Chalmers Mfg. Co., 1002 S. 70th St., Milwaukee, Wis.

Circle 184, inside back cover

Open Drip-Proof Motor—Bulletin 51-B6210G, 5 pp. Contains data and charts on motors in NEMA rerated ratings of ½ to 40 hp and in non-rerated ratings of ½ to 100 hp. Allis-Chalmers Mfg. Co., 1002 S. 70th St., Milwaukee, Wis.

Circle 185, inside back cover

Spray Lubrication Equipment—Bulletin 60A, 8 pp. Contains pictures and data on equipment for heavy open

(Continued on page 364)

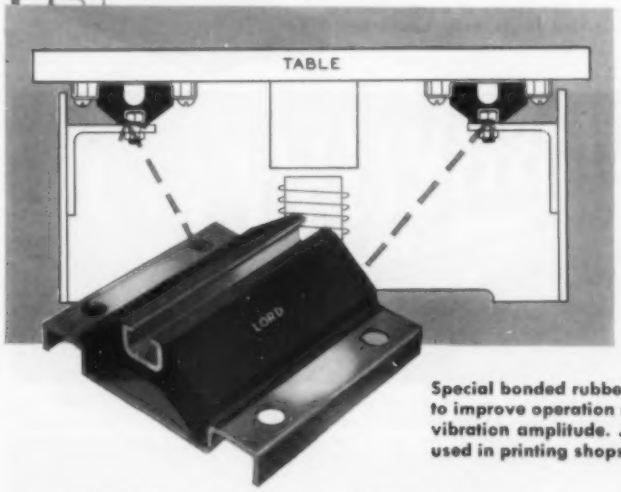
LORD puts vibration control to work!

gives paper jogger greater amplitude with less power input

Vibration, usually an undesirable effect to be minimized, can also be converted into useful work. This requires precise control for maximum effectiveness.

An example of this is the electromagnetic pulsations used by the Syntron Company on its PJ-15 and CPJ-15 Paper Joggers. LORD bonded rubber channel mountings control these vibrations, increasing their amplitude and producing more effective operation with less power consumption.

To provide uniform table motion and give the desired amplitude at the required frequency, the dynamic stiffness of the two LORD mountings must be closely controlled. These mountings, designed and produced to meet Syntron's strict requirements, are typical of the results when LORD engineering is applied to your vibration problem. LORD's experience in Engineered Vibration Control and Bonded Rubber Products is unsurpassed. Contact your nearest LORD Field Engineer or the Home Office, Erie, Pennsylvania.



Special bonded rubber mounting (left) was Lord engineered to improve operation of Syntron Paper Jogger by increasing vibration amplitude. Jogger vibrates at 3600 c.p.m. and is used in printing shops and binderies to increase production.

NEW YORK, N. Y. - Circle 7-3326 | PHILADELPHIA, PA. - LOcust 4-0147
CLEVELAND, OHIO - SHadyside 9-3175 | DAYTON, OHIO - Michigan 8871
DETROIT, MICH. - TRinity 4-2060 | CHICAGO, ILL. - Michigan 2-6010
DALLAS, TEXAS - Riverside 3392 | LOS ANGELES, CAL. - HOllywood 4-7593
BOSTON, MASS. - HAncock 6-9135
"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PENNSYLVANIA

LORD BONDED RUBBER

designers and producers of bonded rubber products since 1924

HOWELL MOTOR BRIEFS

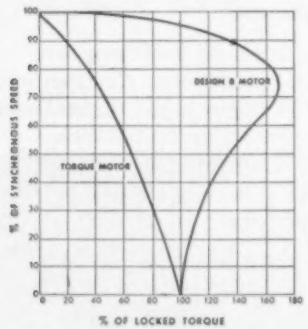
Quick facts for those who apply and specify electric motors

Torque Motors: *They Stall and Hold*

If you want a machine drive to not only apply power but also hold a position or maintain a constant tension, a Howell torque motor may be your solution. Here's a motor that can be stalled, while exerting maximum torque for predetermined intervals, without burning out . . . that can also apply virtually constant torque while operating at a given sub-synchronous speed.

Linear Speed-Torque Curve

The graph below shows this motor's almost linear speed-torque characteristics as compared to a conventional motor's. The secret lies in the design, which produces increased torque while limiting locked rotor current.

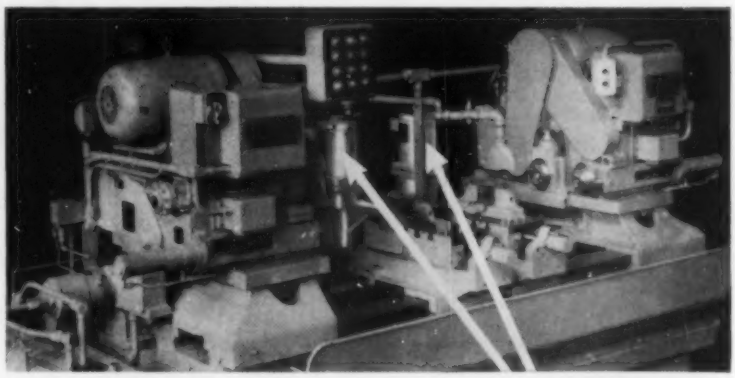


Adaptable to Many Uses

In addition to the clamping, elevator drive and reel tension applications shown at right, Howell torque motors are doing a great many other jobs. Door opening and closing, take-up reeling of film and carbon paper, activating electrical starter contacts and a variety of clutching, chucking and braking operations are among them. They do a quieter, more positive job than many mechanical devices and can often effect important simplifications in machine design.

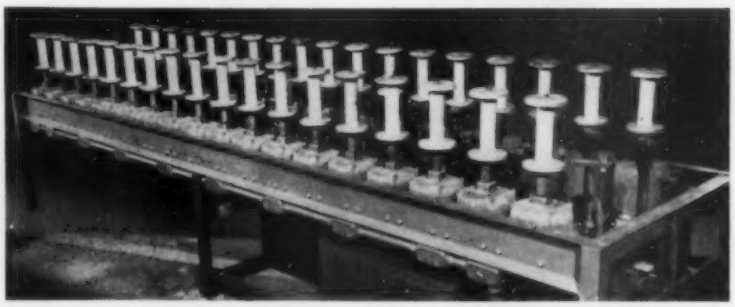
Typical Howell Series 100 Torque Motor

Write us details of *your* requirements. We'll be glad to make suggestions and a quotation.



Two Howell Torque Motors operate clamps for positioning and holding the workpiece on this high-speed, automatic milling and centering machine. Seven Howell motors in all provide power for this precision operation.

A Howell Torque Motor operates the brake and the elevator driving mechanism shown at right. Opening and closing of elevator doors is another typical torque motor application.



A constant, precise tension is maintained on monofilament plastic thread, after extrusion, by the 36 Howell Torque Motors on this winding machine. Multi-speed reeling and winding operations, particularly, are simplified by the use of torque motors in place of geared mechanical devices that are relatively expensive and difficult to keep in adjustment.

HOWELL Red Band MOTORS

HOWELL MOTORS

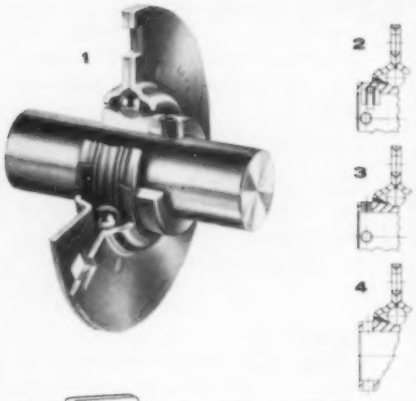
HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

Aetna

SEALED, PRE-LUBRICATED BALL BEARING package UNITS

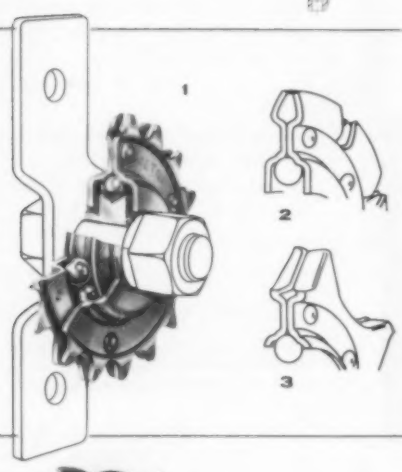
Easy To Apply . . . Require No Maintenance . . . Inexpensive



ADAPTER UNIT

Designed for light-duty moderate-speed applications, this multi-purpose economy-priced unit mounts easily, quickly, wherever shafts can be supported—on sheet metal or any semi-rigid structural members. Sealed, pre-lubricated bearing is self-aligning; takes radial, thrust or combined loads. Available in 4 shaft-locking types, (1) with eccentric locking collar,* (2) with ball lock,‡ (3) with two set screws,‡ (4) drilled for roll-pins.‡

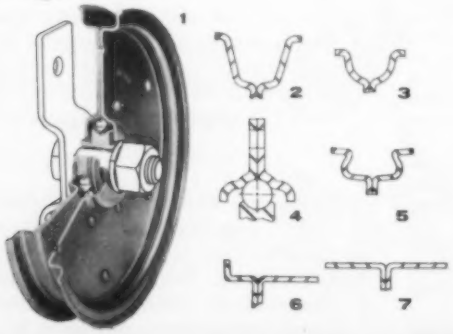
*Standard ‡On special order



SPROCKET IDLER UNIT

A sprocket idler and pre-lubricated, sealed, ball bearing —*all-in-one*. Bearing has triple-capacity lubricant chamber, full complement of balls for greater load capacity, 4-point ball contact for greater rigidity, case-hardened inner and outer races. Bore sized for ⅜" or ½"* mounting bolts—available with sprockets (as illustrated) to fit (1) standard pitch, (2) extended pitch roller chain or (3) detachable link chain.

*On special order



BELT IDLER UNIT

Designed and built-to-be-installed-and-forgotten this permanently lubricated, sealed-for-life idler unit requires no re-lubrication, no maintenance of any kind. It combines bearing, seals, and pulley in a single, compact, easy-to-install *package* assembly. Bore sized for ⅝" or ½"* mounting bolts. Sheaves (available in 7 types illustrated) and bearing outer race are of heavy-gauge, case-hardened steel.

*On special order

GET THE FACTS . . .

See how these low-cost units can be adapted to either your current or projected equipment designs with minimum, or no, engineering alterations. Write us or call in our local expert, your nearby Aetna distributor.

Aetna

40 Years

AETNA BALL AND ROLLER BEARING COMPANY
Division of Parkersburg-Aetna Corporation
4600 Schubert Ave., Chicago 39, Illinois

Comfort...

NEEDS LUBRICATION, TOO!

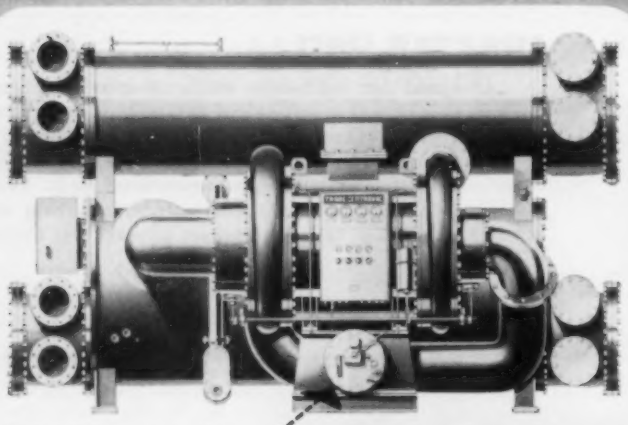
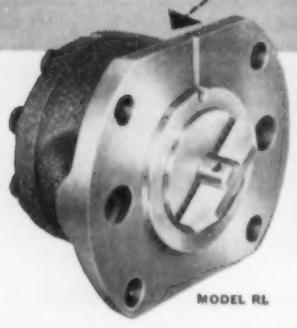


Photo of CenTraVac, courtesy The Trane Company, LaCrosse, Wisconsin

How

TUTHILL PUMPS Help the Trane "CenTraVac" Keep Customers Cool



MODEL RL

In developing the unique CenTraVac hermetic centrifugal refrigeration unit, Trane engineers required a positive lubrication system that would be both simple and foolproof. For the heart of this system, they selected the Tuthill Model RL—a positive displacement, internal-gear rotary pump with automatic reversing feature.

The performance characteristics of this pumping unit make it most dependable for pressure lubrication service. Model RL holds its prime and delivers the capacity needed instantly—a "must" in the CenTraVac, since full oil pressure must be developed before the unit will start—let alone operate.

Quiet in operation—also a "must" in CenTraVac—Model RL is built for long, uninterrupted service. Its automatic reversing feature offers further insurance of positive lubrication, since the pump will deliver from the same port regardless of ultimate direction of shaft rotation.

Whether you need standard or special pumps for lubrication, coolant, hydraulic, or liquid transfer service, you are invited to submit your specifications for recommendations.

Write for catalog data on Tuthill pumps for your specific needs.

See our catalog in Sweet's Product Design File—6b-Tu

TUTHILL PUMP COMPANY

Dependable Rotary Pumps . . . since 1927

939 East 95th Street, Chicago 19, Illinois

Canadian Affiliate: Ingersoll Machine & Tool Co., Ltd., Ingersoll, Ontario, Canada

gearing and slide surfaces. Farval Corp., 3249 F. 18 St., Cleveland 4, Ohio.

Circle 186, inside back cover

Drawing Devices—Catalog, 20 pp. Contains data on rulers, plotting and computing instruments. C.-Thru Ruler Co., 827 Windsor St., Hartford, Conn.

Circle 187, inside back cover

Motor Drives—Bulletin 1610B1P, 8 pp. Contains information on drives ranging from ½ to 25 hp. Worthington Corp., Harrison, N. J.

Circle 188, inside back cover

Valves—Data unit 294, 2 pp. Gives details and features of drain or sampling valve in sizes from ¾ in up to 2 in. Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.

Circle 189, inside back cover

Thermosetting Adhesives—Bulletin, 28 pp. Data, specifications and chart on Tygoweld adhesives. U. S. Stoneware, Akron, 9, Ohio.

Circle 190, inside back cover

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

Hydraulic Valves—Catalog H-12, 92 pp. Contains information, drawings and flow schematics for controlling fluid power when used to control the operation of cylinders and motors. Commercial Shearing and Stamping Co., 1775 Login Ave., Youngstown 1, Ohio.

Aluminum Handbook – Hard-cover book, 175 pp. Data and 140 tables on wrought alloys; sheet and plate; wire, rod, and bar; extrusions; tube and pipe; electrical conductors; structural shapes; forgings and casting alloys. Section on mill products discusses sizes, properties and tolerances. Aluminum Co. of America, 781 Alcoa Bldg., Pittsburgh 19, Pa.

Washers and Stampings—Catalog No. 40, 20 pp. Contains specifications, pictures, and price list of assorted washers. Wrought Washer Mfg. Co., 2100 S. Bay St., Milwaukee 7, Wis.

SHARON *Quality* STEELS

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- ot and Cold Rolled Strip
- alvanite* Strip
- utlery Steel
- old Rolled Spring Steel
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- ates
- ooperage Hoop
- ectrical Sheets
- oxidized Sheets
- alvanite* Sheets
- alvanized Sheets
- ng Terne Sheets
- ameling Sheets
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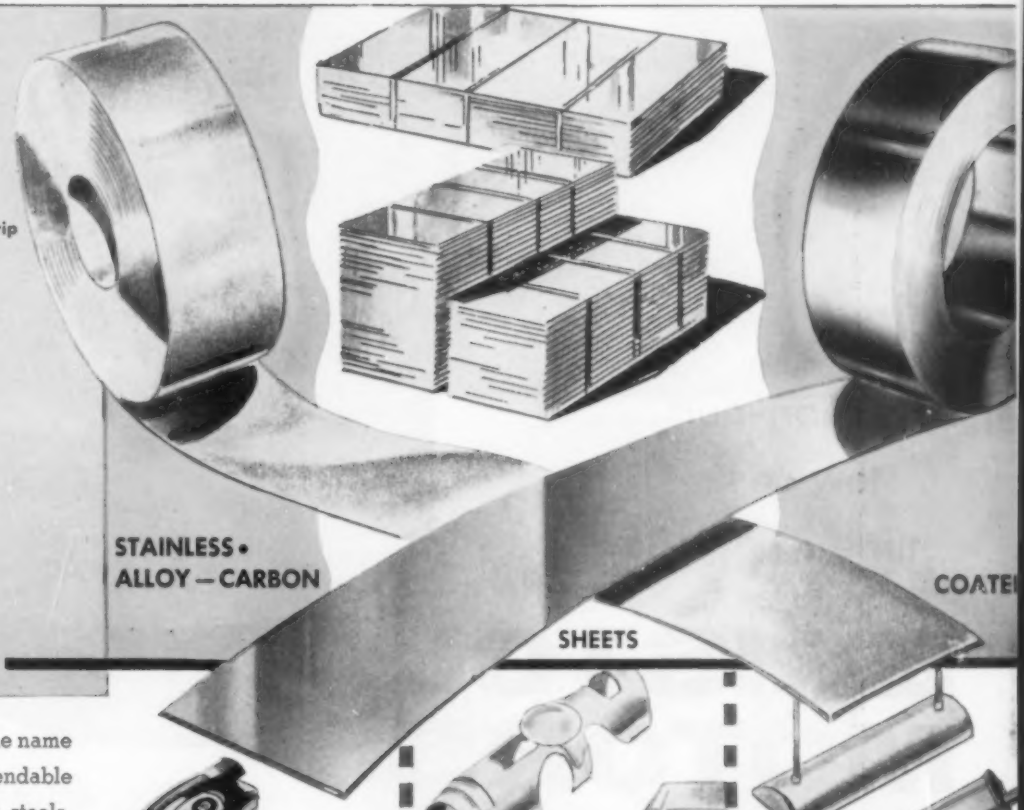
- r - Ten
- A. X.
- pper Bearing Steel

*ade Name



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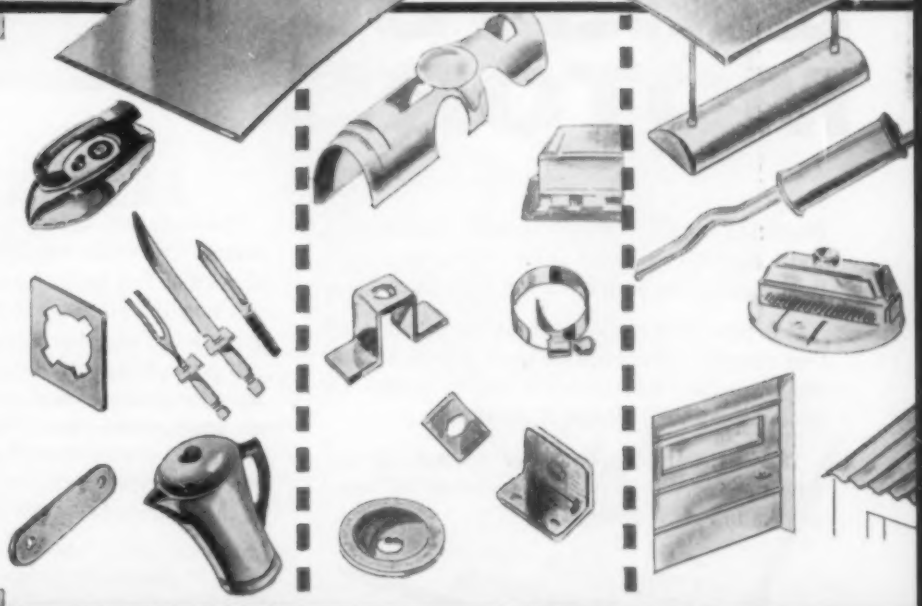

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Actual dimensions are 3" long and 2⅛" in diameter. This relay is a basic 2 switch unit for stud-type mounting. Others are available.

Precision-built,
low cost
time delay relay by

BRISTOL MOTORS

Featuring the Circle B synchronous timing motor and a solenoid operated differential-type clutch, this relay is compact, accurate and dependable.

It is primarily for general timing applications that require instantaneous reset action, such as the protection of electronic tubes, timers for photography, and alarms or signals.

The Circle B relay is available in practically any time range from 15 seconds to 3 months based on 270° full scale setting.

The reset time of the relay is well under 1/5 of a second. The timer has repeat accuracy of better than 1% of full scale. Designed for dependability and long life, you can expect better than 1,000,000 operations from this circle B relay.

If you now use or plan to use time delay relays or other types of timers, check with Bristol. There are many variations of this basic relay, including different switch combinations and mountings. Non-reset types of timers are also available. Write to the address below for further information.

BRISTOL MOTOR DIVISION
VOCALINE COMPANY OF AMERICA, INC.
COULTER STREET, OLD SAYBROOK, CONNECTICUT

save money, minutes, metal

with B&W MECHANICAL TUBING

CARBON • ALLOY • STAINLESS

Countless hollow parts and products now being made from solid stock can be fabricated more economically from tubing. The hole is there, eliminating heavy drilling with all its attendant waste. And the wide range of sizes, shapes, analyses, finishes and heat-treated conditions in which B&W Mechanical Tubing is available, make it a semi-finished product in itself — reduce all your machining operations to the minimum.

Get the facts on savings from Mr. Tubes, your link to B&W and your local B&W tubing distributor.

Write for Guide to the Use of Seamless Mechanical Tubing, Technical Bulletin 340.

The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

B&W TUBULAR PRODUCTS DIVISION

TA-5031 (O)

Seamless and welded tubular products, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels

here's

LOAD PROTECTION on a New Level of Efficiency

because ONLY

Faultless SPRING ACTION CASTERS

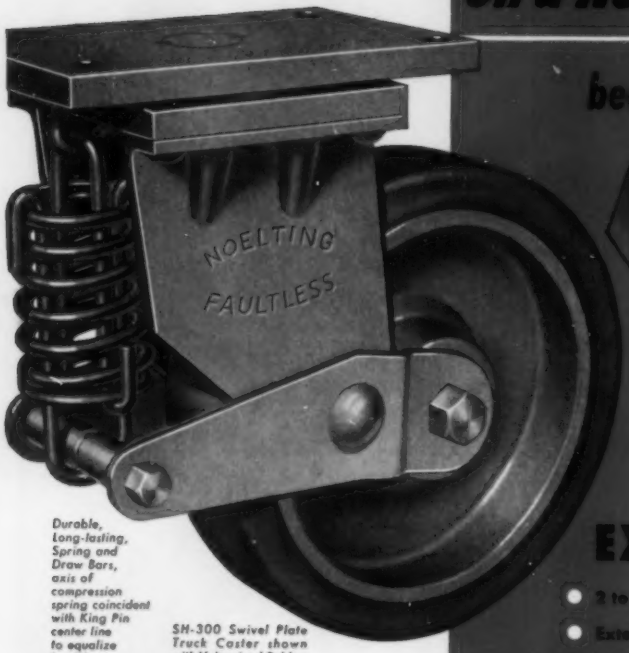
have these

EXCLUSIVE FEATURES

- 2 to 1 Lever Arm reduces shock—lengthens Spring life.
- Extended Wheel Offset for easier swiveling.
- Shock absorbing spring under compression lengthens life of bearings, raceways, wheel, etc.
- Springs of various load capacities easily interchanged to suit requirements.
- Standard Wheels, 3 types, easily interchanged.

This unique caster construction maintains a level load on trucks moving over irregular floors. Wheels contact floor surface at all times—eliminate bounce—don't raise truck when mounting obstacles.

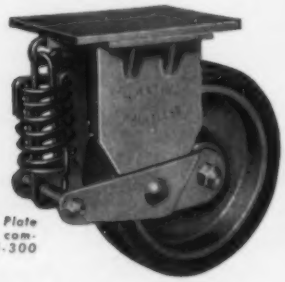
Already time-tested by leading industrial engineers, this Caster is acclaimed for its use of standard, interchangeable wheels . . . absorption of high impact shocks through use of a large, durable spring *under constant compression* . . . spring and draw bar assembly a separate member. Write for catalog data with complete load capacities and specifications.



Durable, Long-lasting, Spring and Draw Bars, axis of compression spring coincident with King Pin center line to equalize load force

SH-300 Swivel Plate Truck Caster shown with Vulcanized Rubber Tread Wheel

Note how large, long-lasting spring compensates for floor irregularities, eliminates bounce or shock, protects both load and caster.



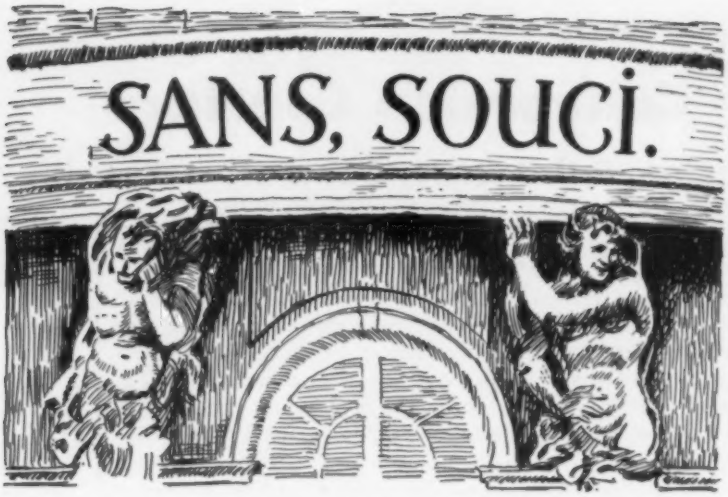
SH-700 Rigid Plate Truck Caster companion to SH-300 Series

SH Casters take jolts out of water tanks for Loading Air Line.

SH Casters maintain smoothness of jet engines moved over rough floors.

FAULTLESS CASTER CORPORATION, EVANSVILLE 7, INDIANA

Offices in Atlanta, Baltimore, Boston, Buffalo, Chicago, Cleveland, Dallas, Detroit, Grand Rapids, High Point, Indianapolis, Los Angeles, New Orleans, New York, Philadelphia, Portland, St. Louis, Seattle. Canada; Stratford, Ontario



Ad Libbing by The Editor

A few weeks ago I had occasion to take a trip down to Manheim, Pa. for a visit with Vincent Alexander and his associates at Manheim Manufacturing and Belting Company. Vince took us over to nearby Lititz which is famous for two things. One is that George Sutter, who discovered gold in California, came from Lititz. Secondly, Lititz is the birthplace of the famous pretzel. It is a typical Pennsylvania Dutch town.

For the benefit of those who may not know these delicious little bakers' products, a pretzel is made by taking a relatively long thin cylindrical piece of dough and twisting it into a shape something like the letter B, and then baking it. To me it was always a fascinating sight to see those men "bending pretzels." The piece of dough, about one-quarter of an inch in diameter and perhaps nine or ten inches long, would come along on a belt conveyor and the man would grab each end of the stick of dough between two fingers and with a twist of the wrist he would put it into its intricate shape. Indeed, he did it with such speed that it was impossible to see exactly how he did it. That's what made it so fascinating to watch. It was generally claimed that the operation was so intricate that no machine could be designed to do it mechanically.

In order to make our visit complete, our Manheim hosts decided to take us around after lunch to a pretzel factory. Believe it or not, the first factory we went to had recently installed automatic machines, designed and built by American Machine & Foundry Company, which bent the pretzels automatically. In fact, the whole operation of making the pretzel was automatic from beginning to end.

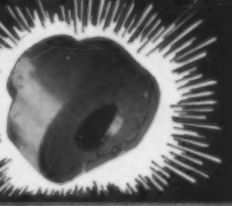
Our hosts quickly decided that we should go to another factory to observe the old hand operation. We got there and learned that they also had automatic machines for manufacturing pretzels and they informed us that every factory in town was now mechanized. The pretzel benders had been put out of business by the product engineers. Which also shows that the Pennsylvania Dutch are progressive in adopting new ideas. So I must tell a little about these thrifty people.

Arriving in this country even prior to the Revolutionary War, many Germans settled in the Lancaster-Reading-Allentown-Bethlehem region of Pennsylvania. Over the years they lost contact with Germany. When new things came along they had no way of finding out the German names, and they were thus left entirely to their own devices when it came to building their language.

To meet this situation, the Pennsylvania Germans resorted to direct translation of the American names. They built the new words by translating the roots of the English words. Having come from Germany originally, they were experts at this. When the railroad came along and they found it necessary to make up a word to mean railroad, they simply took the German word for rail, which is "Riegel" and the German word for road, which is "Weg" and came up

(Continued on page 372)

YOUR BEST BET



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The Engineered Bronze

BEARINGS
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BUSHINGS
•
WEARING PARTS

SUPERIOR SERVICE GUARANTEED OR YOUR MONEY BACK! Special formulas, developed for specific or unusual conditions. Will not cut or stick to the shaft under ordinary operating conditions. Carry on during temporary lubrication failures. Absolutely will not powder in severest service.

HIGHEST QUALITY MACHINING to precisely controlled tolerances. Difficult oil grooving . . . smooth grooves, even around acute bends . . . no sharp edges or burrs . . . better lubrication because there is no "wiping" action. Also available rough cast.

SEND PRINTS and condition of operation for recommendations and quotations.

The American Crucible PRODUCTS CO.

"Bearing Specialists Since 1919"

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Please send free literature and service data sheets on Promet Bronze.

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Chromate Conversion Coatings

for Corrosion Protection, Paint Base, Decorative Finishing

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a nonporous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

If your company is manufacturing or buying parts or complete assemblies made from or plated with any of the more common non-ferrous metals—zinc, cadmium, aluminum, magnesium, silver, copper, brass or bronze—you've probably already run up against the question of finishing these surfaces with a chromate conversion coating. These coatings are used to protect against corrosion, or to provide a base for paint or to provide a decorative finish for sales appeal or shelf life. Since chromate conversion coatings represent a relatively new means of obtaining these finishes, this digest of facts to consider may be of value to you.

1. THE COATINGS THEMSELVES. There are many brands on the market. All are similar in many ways. Each, of course, offers its own specific advantages and these may relate to operating techniques, performance under actual use conditions, cost, availability, etc. Naturally, you'll want to choose a coating that is widely known and accepted under both military and civilian specifications.

2. THE COMPANY BEHIND THE PRODUCT. Is it a reliable, established organization? Does it offer experienced technical service, both from the field-engineering organization as well as the home office and laboratories? The man who sells and services your installation should be thoroughly familiar with not only chromate conversion coatings and their applications, but also with the characteristics and performance of related finishing operations such as precleaning, electroplating, painting, etc. This is most important since all steps of the finishing cycle must be functioning properly for the satisfactory performance of the ultimate finish produced.

3. AVAILABILITY OF THE PRODUCT. Ideally, of course, the material should be readily available to you from nearby warehouses to avoid time loss in long distance shipping and to provide emergency service, should the need arise.

4. COST. Naturally, the initial price of the material is important to you. However, just as you consider ultimate cost when you are buying mechanical equipment, ultimate cost must be considered for these finishing chemicals. So, it will pay you to investigate consumption costs, labor costs and the other factors which go into the determination of ultimate cost. Further, cost alone gives no indication of product performance, so careful attention must be given to the purpose the finish must serve and the value that finish will add to your product.

5. FACILITIES FOR RESEARCH AND DEVELOPMENT. Perhaps the existing types of chromate conversion coatings do not include a compound that will accomplish exactly what you wish. Then, it is important to deal with a supplier who has adequate research and development facilities available to work with you to produce a material to meet your needs. Naturally, such a project is seldom completed overnight. But, with complete cooperation and confidence from both you and your supplier, chances are a satisfactory program can be completed.

These are the concepts of sales and service on which we, Allied Research Products, Incorporated, have developed and marketed the line of Iridite chromate conversion coatings . . . superior product performance, complete sales and technical service, easy product availability, economical cost, extensive research and development facilities. No doubt you are familiar with our line and have seen this trademark—

IRIDITE®

—in our advertising, technical literature or on shipping containers in your plant. Remember this trademark when you're buying or investigating chromate conversion coatings for your company. It's your assurance of quality, economical products from a reliable and established company, skilled sales and technical service from both our home office and a national network of representatives, immediate availability from warehouses in strategic industrial areas and our willingness to work with you to develop new finishes to meet your needs, should the present line fall short.

For complete information on Iridite chromate conversion coatings, write today for your free copy of our technical data file. Or, for immediate advice, call in your Allied Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

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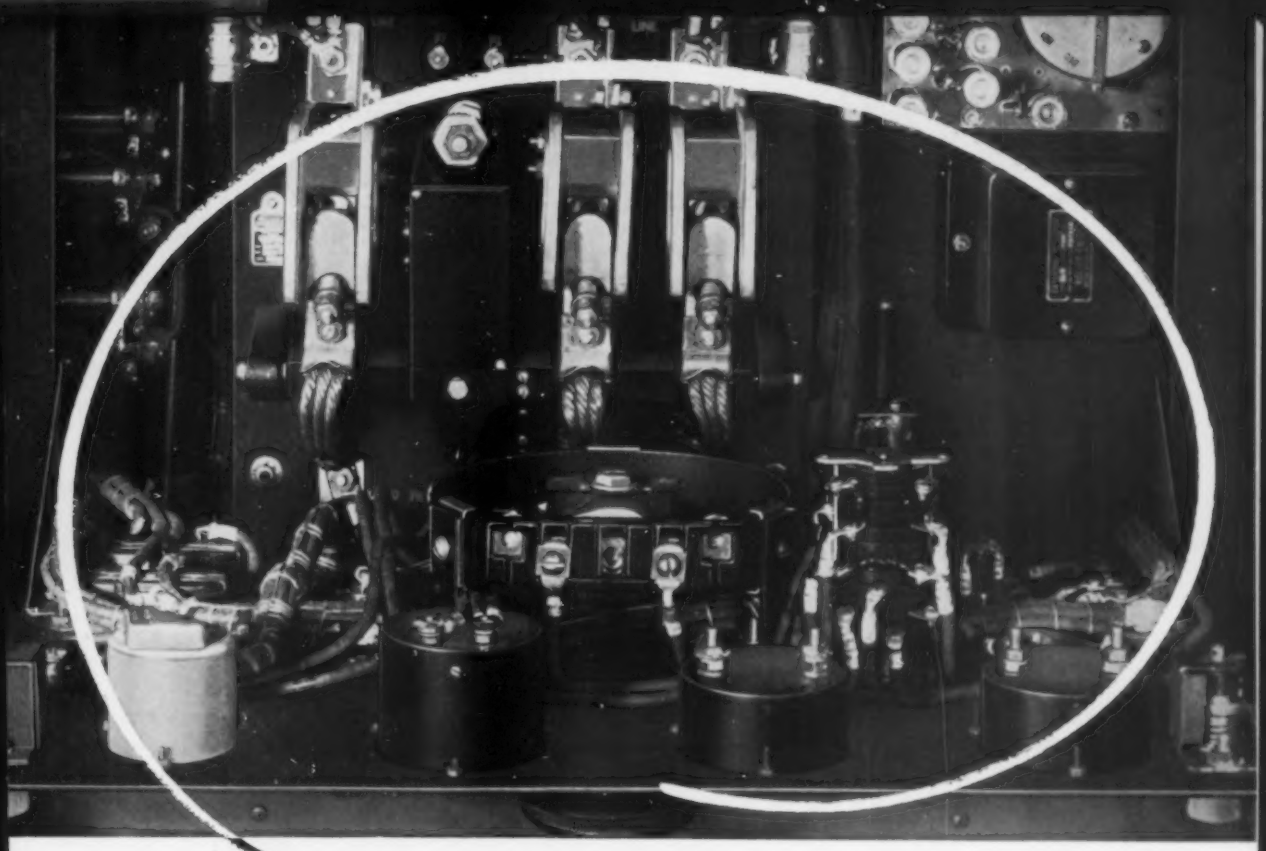
Manufacturers of Iridite chromate conversion coatings for corrosion resistance, paint systems, final finishing of non-ferrous metals; ARP Plating Brightener & Chemicals. West Coast Licensee—L. H. Butcher Co.



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CO silver alloy contact design, edgee wound copper blowout coils, arc elds, powerful bipolar magnet and rigid construction of all parts, insure dependable operation. These features aided International Fermont in meeting rigid Army specifications which call for:

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Write for catalog data on ASCO Contactors: A-C and D-C, normally closed, normally open and double throw, also special applications for sign flashing, street lighting and heater control panels.

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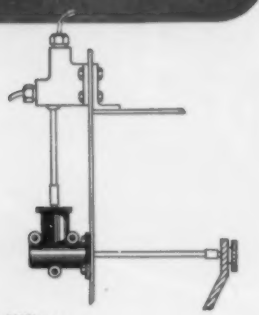

There's an ANGLgear to solve virtually any 90° power take-off problem on either manual or power-operated equipment.

Replace bulky chains and sprockets with ANGLgear, the modern right-angle power take-off. High capacity ANGLgear requires little space and can be mounted four different ways. Thus ANGLgear is easily incorporated in your power transmission system.

You can depend on ANGLgear for long, maintenance-free service. Rugged ANGLgears have hardened bevel gears, ball bearings, and are permanently sealed and lubricated.

Why pay for expensive custom-made drives? Standardized ANGLgear is available immediately from stock in 3 sizes and 12 models, offering you 1-1 or 2-1 gear ratios and 2- or 3-way shaft extensions. See our literature in Sweet's product design file; then contact your local distributor or write us for information.

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with the word "Riegelweg," meaning railroad. On the other hand, the Germans in Germany translated the French name for railroad "chemin de fer," which means, "road of iron." So the Germans call a railroad an "Eisenbahn," or iron-road, which does not even sound like Riegelweg.

As time went on the Pennsylvania Germans, usually called Pennsylvania Dutch, built up what in substance is an entirely new language and for want of a better name it is called Pennsylvania Dutch. The fact that a German cannot understand the language indicates the degree to which it deviates from the original German. And exactly in the same manner that the Pennsylvania Dutch translated English roots into German roots in order to build new words, likewise did they translate the German idioms word for word into English. "Mach das Licht aus," meaning, "put out the light," becomes, "make the light out," when the Pennsylvania Dutchman wants to be in the dark.

Sometimes the situation can become quite amusing. One day, a group of Lehigh professors were eating lunch in Harry Ruthart's restaurant in Bethlehem. It came around to the dessert and one of the profs asked the Pennsylvania Dutch boy who was waiting on us, "What kinds of pie do you have?" Promptly the waiter answered, "Apple, peach, cherry." Then the prof asked, "Is that all?" And the reply was, "No that is not all, that is what we got."

Word Significance

Of course, when one trys to reason concerning languages it becomes terribly confusing. Among my student friends at Lehigh was Chemin Chu Fu, a brilliant Chinese who was studying under a Boxer Indemnity Scholarship. He had a great sense of humor. One day I asked him, "Do Chinese students have yells that they shout at their games."

"Of course," answered Chu Fu.

"What do they say?" I stupidly asked.

Chu Fu laughed. "Their yells are just as meaningful and meaningless as those of American students. Both are just much noise."

Too often yelling is "just much noise."

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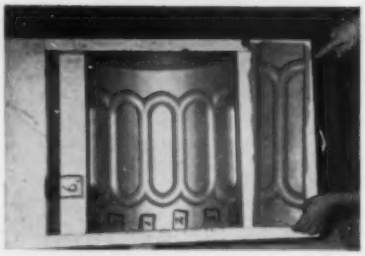

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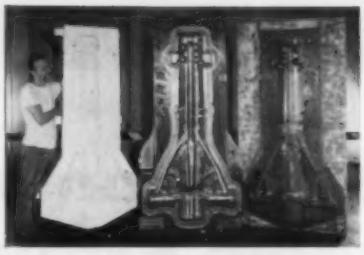

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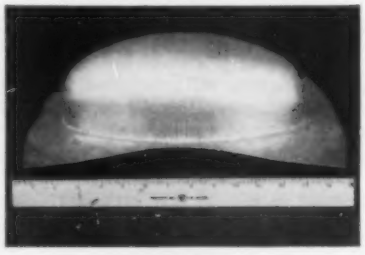

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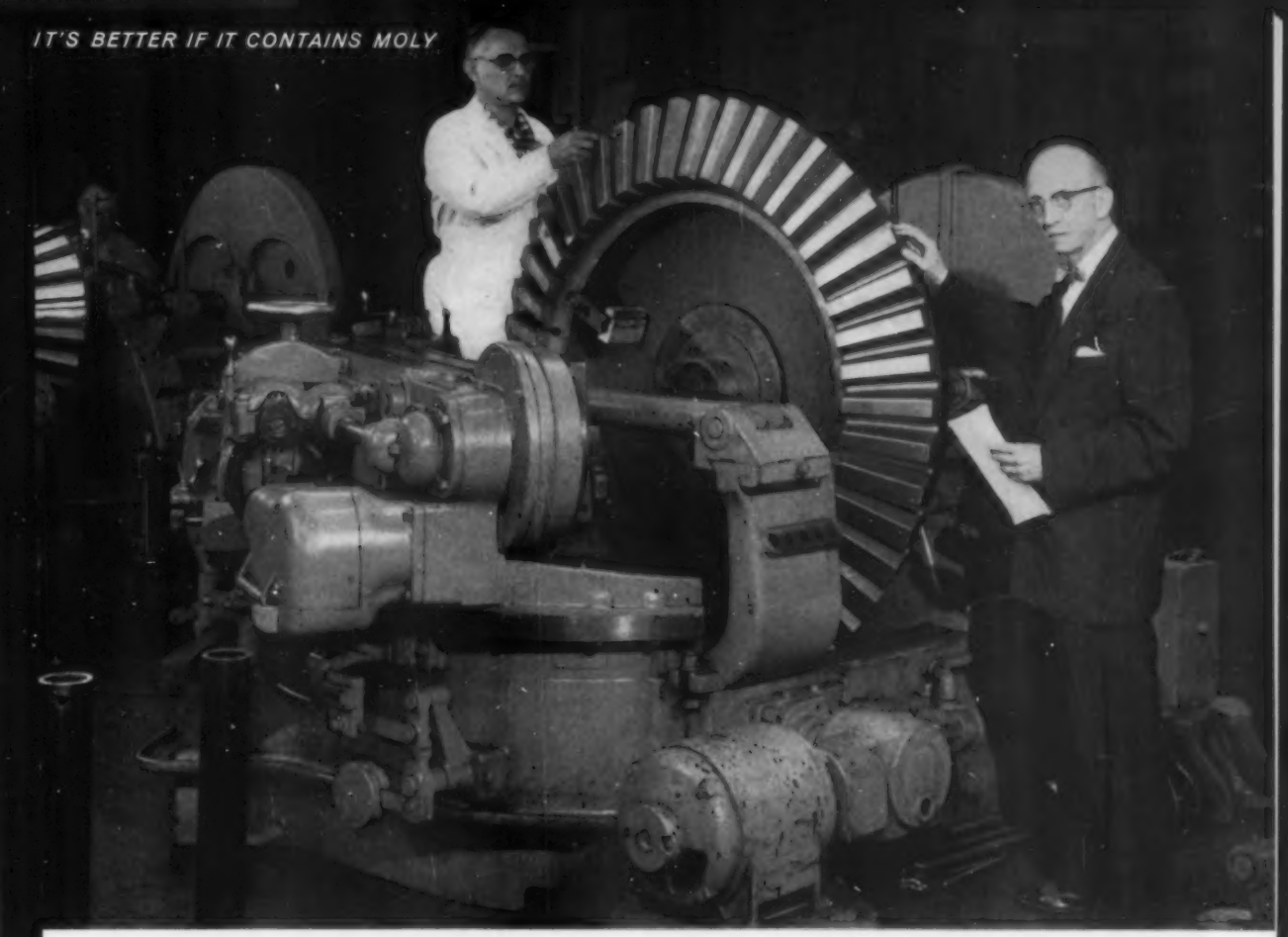


E. B. Smiley, Metallurgist for Illinois Gear & Machine Co., looks over setup of large, heavy duty bevel gear made from molybdenum alloy steel casting. This gear has been rough turned, rough cut and heat treated to 269 to 302 Brinell before finish cutting.

For Strength, Hardness and Machinability gear maker recommends Molybdenum Alloy Steels

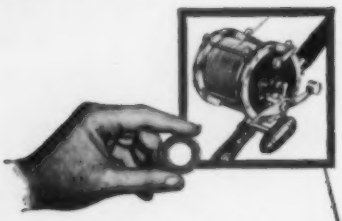
"All of our gears are made to customer specifications, and in many cases these include the use of molybdenum steels," says Mr. Smiley, metallurgist for Illinois Gear & Machine Co. "When our customers specify heat-treated gears of plain carbon steel," Mr. Smiley continues, "we often recommend that they change to 4140 alloy containing molybdenum to achieve high strength and hardenability with good machinability."

Moly steels offer gear users many advantages over carbon steel. Their greater strength and toughness permit the use of smaller weight-saving gears to transmit a given amount of power. Reduced weight and size of gear housings and other components add to the economy of moly steels. And their higher endurance is an important safety factor.

The properties of moly steels are discussed in a new booklet "Moly Steels for Cast Gears". Full technical assistance is also yours for the asking. Write Climax Molybdenum Co., Dept. 61, New York 36, N. Y.

CLIMAX MOLYBDENUM

Boating a world's record Marlin...



1525-lb. Marlin, the women's world's record, caught by Miss Kimberly Wiss on a Penn Senator Reel with friction drag using J-M Style #600 lining.

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Equipment can be controlled more efficiently with J-M Asbestos Friction Materials

Johns-Manville Asbestos Friction Materials meet a wide range of applications. Whether you need a tiny brake material for a fishing reel . . . or a rugged clutch facing for a powerful machine press, Johns-Manville can help you.

Precision manufactured, dependable Johns-Manville Friction Materials are available in low, medium and high friction coefficients. These linings and facings are specially engineered to withstand severe shock, maintain friction stability under critical temperatures, provide smooth action at a low rate of wear. If your requirements demand a friction material that must be custom-made for a special use . . . the Johns-Manville Research facilities are available to help develop that just-right formulation.

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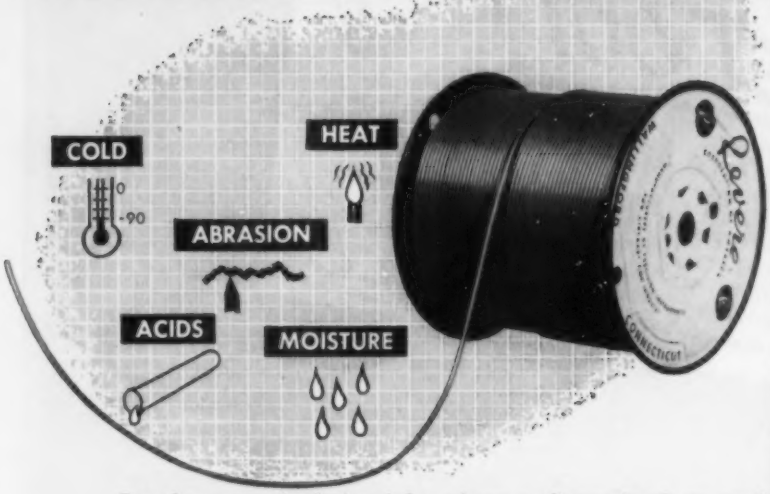

For those tough design jobs where ordinary hook-up and thermocouple wires die from the heat, get brittle in cold, abrade and corrode . . . Revere SPECIALTY wires stand up. Built to MIL and customer specifications, Revere's wide range includes:

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Prompt delivery of standard stock wires. Write for samples and literature on specialty hook-up or thermocouple wire.

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ABSTRACTS

Properties of R. C. 130A Sheet Titanium

Abstracted from "Mechanical Properties of R. C. 130A Sheet Titanium at Room and Elevated Temperatures" by D. C. Hayward, Royal Aircraft Establishment, Farnborough, Hants, England; Ministry of Supply, London, W. C. 2, Tech. Note Met. 214, referenced NACA N-42786.

Mechanical properties in tension and compression were determined on 16 SWG (0.064 in.) sheet at room temperature, 200 C and 400 C in direction parallel, and transverse, to rolling. At each temperature level the modulus of elasticity was found to be the same for tension and compression in the same direction, but transverse values exceeded longitudinal values. Transverse yield strengths exceeded longitudinal yield strengths by as much as 25 per cent in both tension and compression. Similarly, ultimate tensile strength was higher in the transverse direction.

Elongation values decreased with increase in temperature over the range tested. Stress-strain, tangent-moduli and secant-moduli curves are given.

Resistance to Corrosion of Sheet Mg-Li Alloys

Abstracted from "The Corrosion Resistance of Binary Magnesium-Lithium Alloys in Sheet Form" by H. G. Cole, Royal Aircraft Establishment, Farnborough, Hants, England; Ministry of Supply, London, W. C. 2, Tech. Note Met 235, referenced NACA N-42803.

Corrosion tests, by total immersion in 3 per cent sodium chloride solution and by intermittent seawater spray, conducted on sheets rolled from a series of binary magnesium-lithium alloys with low sodium content showed that alloys containing up to 10 per cent lithium by weight had a corrosion resistance approximately equal to that of Mg-1.5 Mn. When lithium content was 12 per cent or above, corrosion resistance fell rapidly. Magnesium-lithium binary alloys up to 5.7 per cent lithium consists of a solid solution of lithium in hexagonal magnesium (alpha phase); from 5.7 to 10 per cent

(Continued on page 380)

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Prove by comparison tests how Parker O-rings seal better and last longer

For trouble-free leakproof sealing, you can depend on Parker O-rings. They are precision molded of superior compounds that have been developed as the result of thousands of tests.

Elongation, tensile strength, compression set ratings, resistance to oils, fuels, chemicals, and high and low temperatures, are determined with care. Then, laboratory and service tests make sure that all rated characteristics are held.

From Parker you can get exactly the *right* O-ring for your *specific* application. We invite you to compare Parker O-rings with any other make. Our engineering service will also help you with designing problems.

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The Parker Appliance Company
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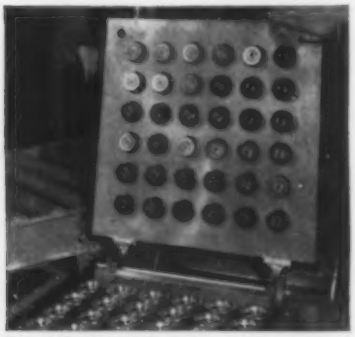
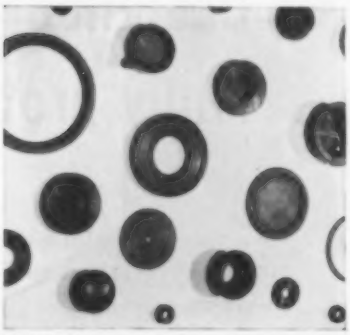
Laboratory and service tests check compound resistance to oils, fuels and chemicals at high and low temperatures ... assuring the long life of Parker O-rings.



Precision molding by exclusive, automatically controlled methods assures close-tolerance fits. Parker has molds for 296 *standard* O-ring sizes. Send for data.



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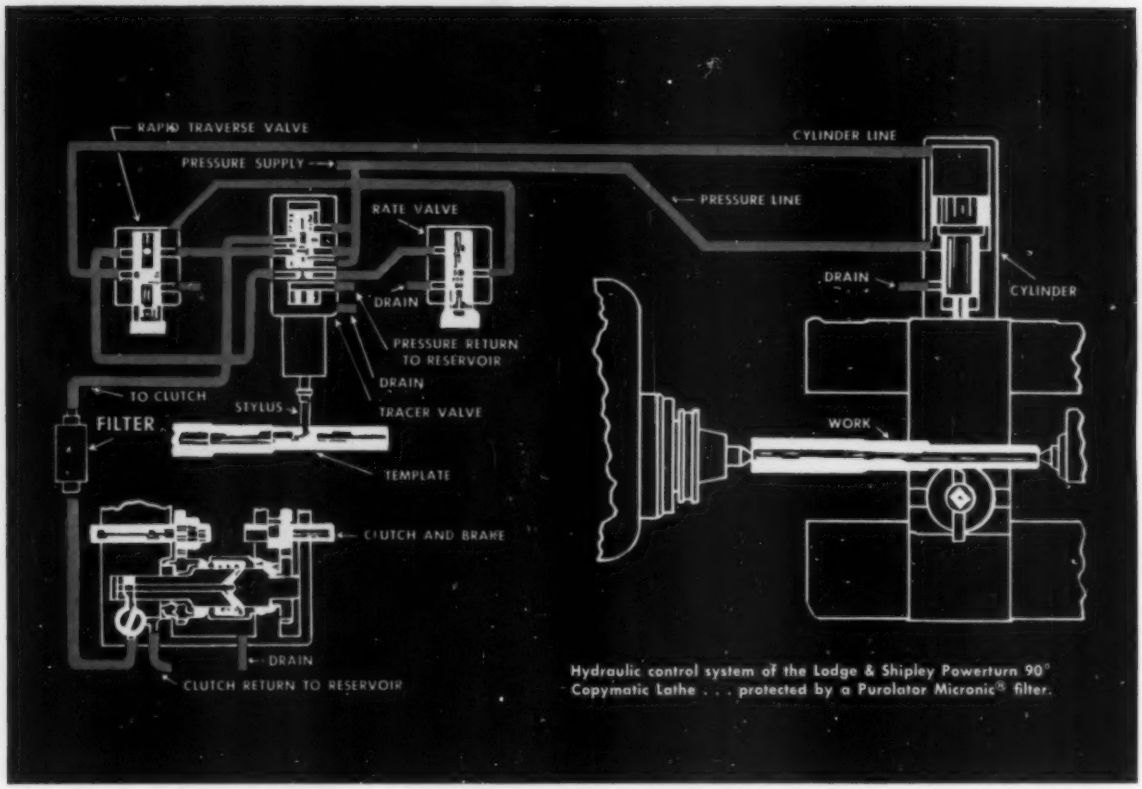

Hydraulic control system of the Lodge & Shipley Powerturn 90° Copymatic Lathe . . . protected by a Purolator Micronic® filter.

Designed for highly accurate control ...fully protected by Purolator Filtration

On a very successful automatic duplicating lathe, this hydraulic control system makes possible both quick, simple operation and a high degree of sensitivity and accuracy. Reliable and uninterrupted operation of a system like this is dependent upon freedom from contaminants. That's why the Lodge and Shipley Company, its manufacturer, made Purolator Micronic® filters an integral part of their hydraulic system.

Purolator engineers recommended a standard filter from their stock of over 2000 models. It more than met the system's special requirements.

The controlled porosity of Purolator's Micronic element evenly filters out contaminant particles as small as .000039 inch. And because it's made of plastic-impregnated cellulose, the Micronic element is not affected by high temperatures, water, or oil.

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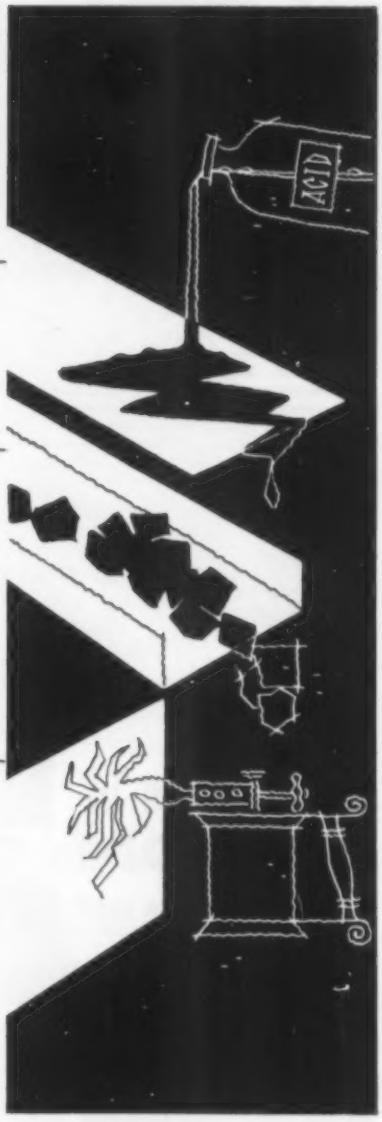

No other finish can give the protection afforded by Porcelain Enamel! This completely inorganic material, combining the strength of steel with flint-hard glass, is unaffected by conditions that would wear-out, rust-out or burn-up other materials. By using Porcelain Enamel in critical applications, designers improve the performance of their products, and at the same time frequently reduce weights and lower costs.

And where beauty and color are desired to increase the attractive appearance and sales appeal of a product, Porcelain Enamel fills every requirement. It is unsurpassed in range of colors and surfaces, and retains its original beauty and color *for life*!

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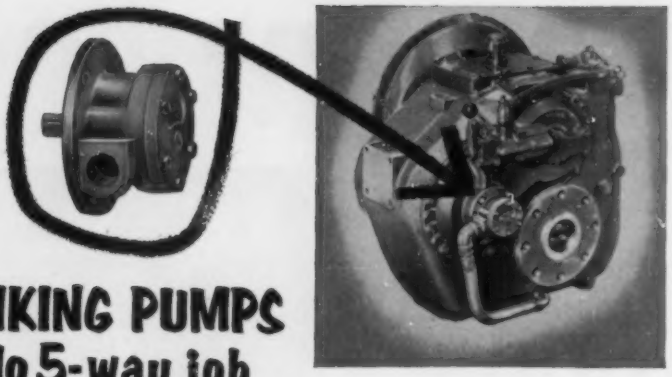

VIKING PUMPS do 5-way job on Twin Disc Clutch's New Marine Gear

Twin Disc Clutch Company, Racine, Wisconsin, designed their new MG-11 Marine gear for the new high speed, high horse power marine engines. They spent three years in research, designing, planning and testing. Viking Pumps were selected to perform five functions—1. Actuate the clutches. 2. Carry heat away from clutches. 3. Give smooth clutch engagements. 4. Reduce clutch plate wear, and 5. Force-feed lubricate meshing gears.

Besides Marine use, Vikings are pumping dependably in petroleum, chemical, foods, and many other fields. If you have a pumping problem, call on Viking. To start, write for bulletin 56Sx.

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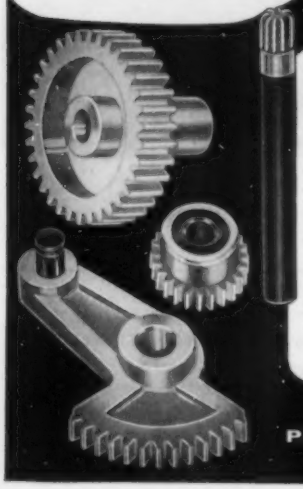
NOW! new economies in NYLON GEARS means savings in gear costs up to 90%



Our many years of pioneering and successful production of Nylon Gears, plus new reduced mold charges, can now make even greater economies for you in the use of Nylon Gears. With the great variety in molds now possible, Nylon should not only be considered as an economy measure but the answer to many problems where a compact design is necessary. Nylon Gears are quiet, durable, efficient and need less lubrication – they mate perfectly with metal gears.

Let our engineers with more than a decade in gear experience show you how Nylon Gears can save you money – let us consider your gear problems during the design process—send blueprints or specs for prompt estimates.

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lithium the alloy has an alpha-beta structure, and above 10 per cent lithium it is a solid solutionn of magnesium in cubic lithium (beta phase).

Resistance to Corrosion of Al-Cu and Al-Cu-Cd Alloys

Abstracted from "Corrosion and Stress-Corrosion Properties of Aluminum-Copper and Aluminum - Copper - Cadmium Alloys" by C. Braithwaite, Royal Aircraft Establishment, Farnborough, Hants, England; Ministry of Supply, London, W. C. 2, Tech. Note Met. 219, referenced NACA N-42788.

Investigation of Al-4.3 Cu and Al-4.3 Cu-0.097 Cd showed that both alloys had high resistance to corrosion under intermittent seawater spray conditions, both with and without applied stress.

The materials were exposed for 18 mo without load, and later tested. It was found that they had not lost any tensile strength. The same materials were exposed under load in excess of the 0.1 per cent yield strength for 18 months without failure.

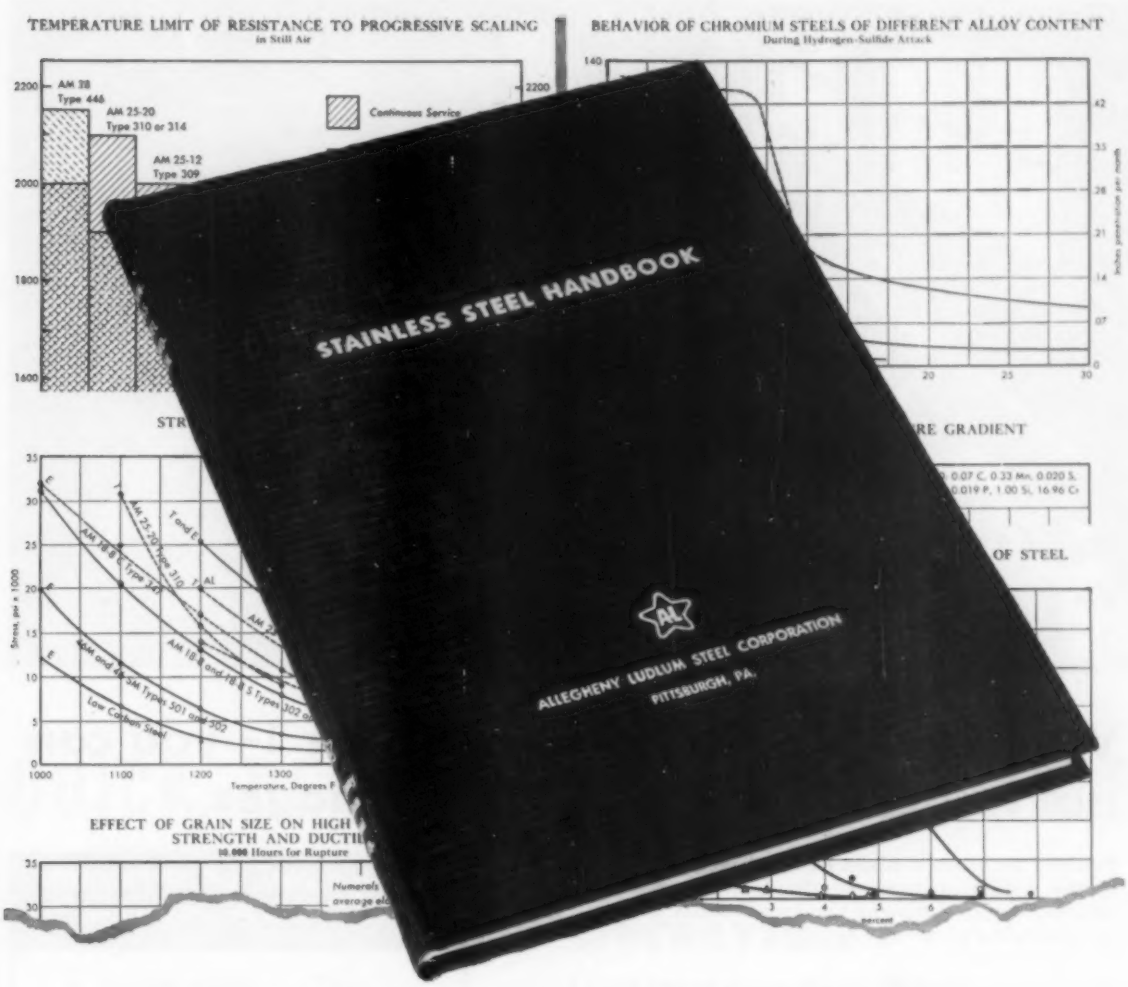
Expensive Steels Make Cheap Gears

Abstracted from "Influence du Choix des Aciers sur la Valeur des Engrenages et Pignons" by O. Giscard d'Estaing, *La Métallurgie* (France), Feb. 1956.

Metal used has very limited influence on cost of finished gears. On short production runs of about fifty units, carbon steel accounts for only 5 per cent of ultimate gear cost. Use of a premium steel would raise metal cost to about 8 per cent, increasing total gear cost by about 3 per cent. Thus for a very slight increase in cost the gear can be made of chrome-molybdenum or nickel-chrome steel. High wear resistance and low incidence of failure of gears so produced result in longer life and make the gears cheaper than those produced from carbon steel. Increased machining costs of alloy steels are more than offset by reduced rejection rates.

Where operating considerations require that gear teeth be subjected to a straightening operation to offset distortion caused by heat treatment, the choice of steel becomes even more important. Straightening of gear teeth is so expensive that any reasonable increase in the cost of the mate-

(Continued on page 384)



Here's 124 Pages of Valuable Data on STAINLESS STEEL

Stainless and heat resistant steel can usually be classed as a critical material, since it not only contains strategic alloys but is indispensable in many vital industrial and armament applications. It is always important, therefore, to make every pound go as far as possible.

The latest edition of our comprehensive 124-page, case-bound Stainless Steel Handbook is ready for distribution now. It will help you to select the right stainless steel and to use it properly. Comprehensive listings of analysis, properties and characteristics of each type will guide you in specifying grades that will do your job most efficiently. Clear, concise fabrication data will help you speed production and cut waste.

Your copy of the Stainless Steel Handbook will be sent—*without charge*—upon request. Our only stipulation: please make your request upon your company letterhead. • Write *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

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For Stainless Steel in ALL Forms—call

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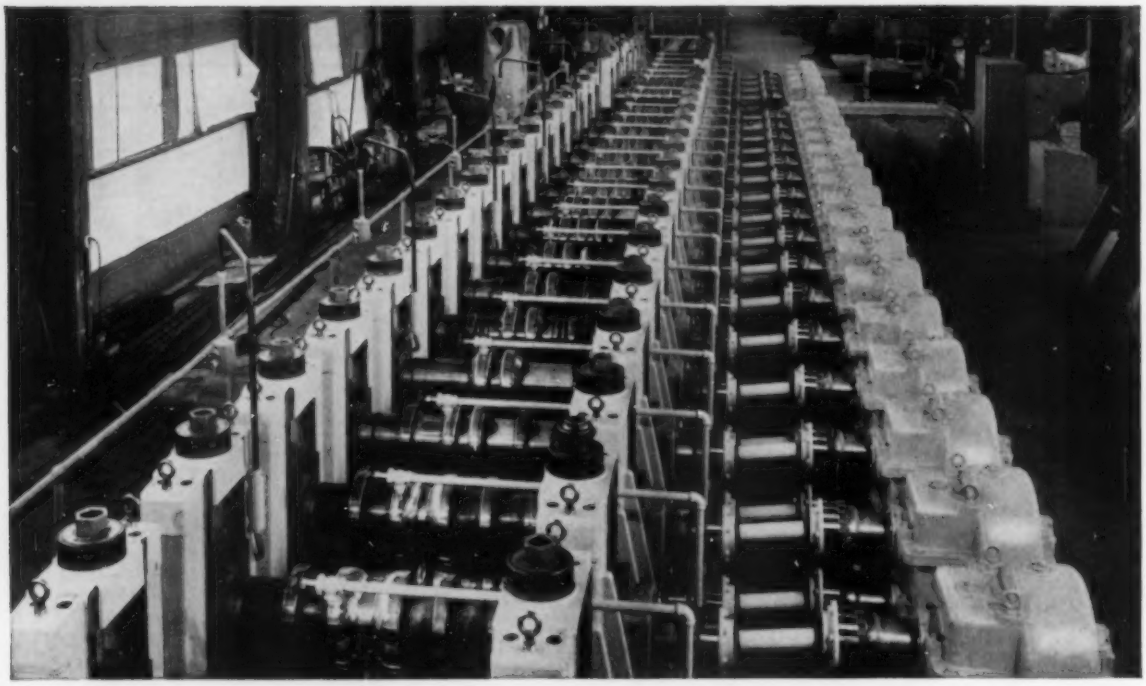


Whether you require 84 joints or 1—you can put to use these Rzeppa advantages

Pictured is the most advanced and largest cold forming mill in the world—developed by the American Roller Die Corporation. In it, 84 Rzeppa Constant Velocity Universal Joints are providing money-saving precision never before possible in this industry.

Here are the advantages you can receive by specifying Rzeppa Joints:

- **Stepped-up speeds.**
- **Reduced down-time.**
- **Smooth flow of power at unbalanced angles.**
- **Higher capacity for size and weight.**

HOW TO GET COMPLETE INFORMATION ON THE PROFIT ADVANTAGES OF RZEPPA JOINTS

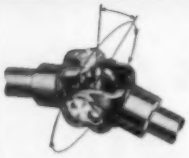
You can get more information on how Rzeppa Joints can fit into your joint application. Write, wire, or phone today. We'll send the brochure or have a factory representative call —as you wish.

RZEPPA (Pronounced "SHEPPA")
CONSTANT VELOCITY UNIVERSAL JOINTS

The Gear Grinding Machine Company 3939 Christopher Detroit 11, Michigan

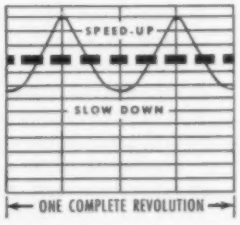
Manufacturers of • Fully Automatic Gear Grinding Machines
• THE DETROIT SCREWMATIC 750

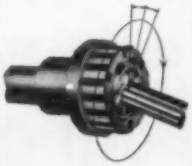
COMPARISON OF OPERATION
Rzeppa Versus Pin or Slipper-Type.



During rotation at a given angle, pin or slipper-type joint speeds up, slows down twice during one revolution.

Solid line shows speed variation for one revolution of pin or slipper-type joint at a critical angle. Note constant velocity of 100% for Rzeppa Joint (dotted line).





Due to its construction features, the Rzeppa Joint always transmits a smooth flow of power even at unbalanced angles. The standard joint cannot meet this test without involved compensating measures.

FOR HUMIDITY CONTROL AND MEASUREMENT

THIS IS THE ONLY HUMIDITY SENSING ELEMENT WHICH RESPONDS ENTIRELY TO CHANGES IN SURFACE CONDITIONS.

THIS IS THE ONLY HUMIDITY SENSING ELEMENT UNAFFECTED BY TOTAL WATER IMMERSION.

QUICK, REPRODUCIBLE, DEPENDABLE

EL-TRONICS HUMIDITY DETECTION

Based on an entirely new principle, low cost El-Tronics humidity sensing elements are completely stable over long periods and over a wide temperature range (—23° to 176° F).

They are applicable over the entire field where relative humidity is measured or controlled including humidifying, dehumidifying, dehydration, drying, air conditioning and packaging.

Instruments illustrated permit application of the El-Tronics Humidity Sensing Element to laboratory and industrial measurement and control.

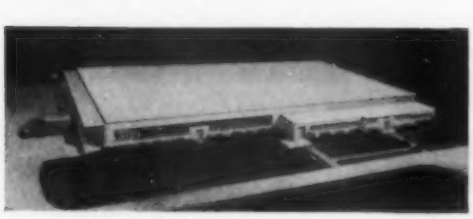
For complete information, write El-Tronics, Inc., Mayfield, Pa.

LABORATORY HYGROMETER
MODEL 101

PORTABLE HYGROMETER
MODEL 103

PANEL HYGROMETER
MODEL 102

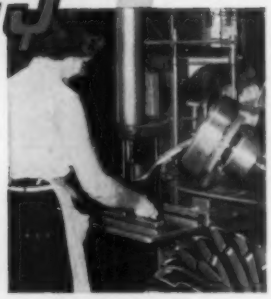
INDUSTRIAL CONTROLS
MODEL 201: ±2½% R.H.
MODEL 202: ±1% R.H.



EL-TRONICS, INC.

FOR *LOW COST* HUMIDITY MEASUREMENT AND CONTROL

Your PRODUCTION DOLLAR$



will show BIGGER PROFIT DOLLAR$

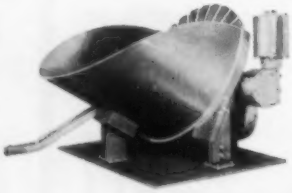
by speeding up your assembling and feeding operations with....

DPS POWER METHODS

● Stepped-up output . . . time saving . . . lower costs . . . Combine them . . . What do you get? A rise in profits. It's today's industrial challenge, and DPS POWER SCREWDRIVERS and SELECTIVE PARTS FEEDERS meet it effectively . . . plus the added advantages of uniform, better work, without interruption and the excessive cost of hand methods . . . More than 12,000 successful applications in progressive plants everywhere prove it . . . It lends assurance that we can meet your requirements. Write us . . . Tell us your set-up . . . We'll make recommendations.

5 SCREW-DRIVING MACHINES
Bench and Pedestal types. Pedestal Model A pictured

BOWL FEEDER
Vibratory type, to select and feed smaller fragile parts



BARREL FEEDER
with stationary ring cover, for heavy-duty, large production runs

DETROIT POWER SCREWDRIVER CO.
2821-A W. FORT ST. DETROIT 16, MICH.

rial can be justified if it reduces the amount of distortion and consequent straightening required.

As is well known, carbon steels are more prone to distortion by heat treatment than nickel-chrome steels, especially if the former are water-quenched and the latter oil-quenched. Air hardening higher alloy steels distort least of all. Often gears can be reduced in cost by over 50 per cent by making them of a material three times as expensive as carbon steel.

From the user's point of view, failure of a gear may involve much more than the cost of a new one, as anyone who has had to replace a gear in an automobile's transmission knows.

From the point of view of design, the function of a gear being the tangential transmission of mechanical energy, the use of a steel with higher mechanical properties permits a proportional reduction in size, which in turn allows for considerable economy.

Papers from AWS National Spring Meeting, Buffalo, N. Y.

Abstracted from "Welded Joint Design for Economy in Structural Fabrication and Erection," by Omer Blodgett, Lincoln Electric Co.

Structural welded designs made without proper consideration for economical welding and erection can result in higher costs than riveted designs. Welded designs are lower in cost when properly made. The author presents an analysis of basic loading conditions met in structural steel work and typical joint designs for those conditions which offer opportunity to reduce the cost of both fabricating and erecting.

Abstracted from "Principles and New Developments of Tin-Zinc Alloys for Soldering Aluminum," by A. S. Laurenson, Belmont Smelting and Refining Works, Inc.

Paper includes data on: nature of chemical reactions and mechanical abrasion for alloying and bonding of tin-zinc solders; effect of aluminum oxide on soldering characteristics; effect of temperature upon the effectiveness of fluxing reactions and mechanical abrasion methods employed in the removal of the aluminum oxide film; advantages and disadvantages of chemical and mechanical methods;

(Continued on page 388)

Dempster-Dumpster—a truck-mounted fork lift designed to handle trash and other bulk materials, shown in dumping position. INSET: "Dacron" is the reinforcement in the V-belts on the 13-inch, 2-groove drive—increasing delivered horsepower, efficiency of hydraulic pump.

How the Dempster-Dumpster's V-belt drive efficiency was increased by premium V-belts reinforced with DACRON

REG. U.S. PAT. OFF.

The lifting and steering power of the Dempster-Dumpster generates from a single hydraulic pump driven by V-belts. To insure dependable, slip-free operation and positive starting at this important spot, Dempster Brothers, Inc., switched to premium V-belts reinforced with Du Pont "Dacron"* polyester fiber. During the six years since the change, the belts have been proving their superiority on hundreds of Dempster-Dumpsters in use throughout the country.

Slippage and stretching have been sharply reduced by the 40% greater strength of belts made with Du Pont "Dacron". Two premium V-belts now do the work formerly handled by three standard belts. The belts remain stable . . . deliver more horsepower from the pump. And the ability of these belts to withstand greater shock loading assures fewer replacements, more efficient, trouble-free operation.

In designing *your* next drive, investigate the advantages of premium V-belts made with "Dacron". They combine the unique properties of the "Dacron" yarn made by Du Pont and the highest skills of the leading V-belt manufacturers. For a list of manufacturers using "Dacron" in premium V-belts, write to E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Dept., Wilmington 98, Delaware. Premium V-belts shown in above photo were manufactured by the U.S. Rubber Company.

6 REASONS FOR USING PREMIUM V-BELTS REINFORCED WITH "DACRON"

- Transmit up to 40% more horsepower.
- Withstand greater shock loading.
- Longer flex life.
- Cut downtime.
- Low stretch.
- Require less maintenance.

***"Dacron"** in V-Belts* DU PONT

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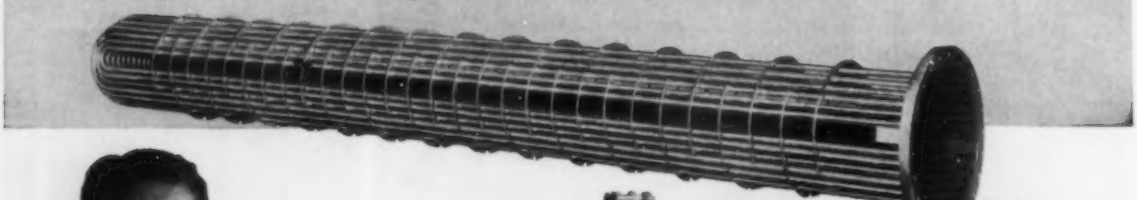
**"Dacron" is Du Pont's registered trademark for its polyester fiber.*

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

"We Have Found a Difference in Condenser Tubes"

"Exceptional size uniformity in Summerill Tubing led to major cuts in our production costs."



L. E. LOOS
Manager of Purchases
The Vilter Manufacturing Co.

Representative
Vilter UNI-CHILLER

"As Manager of Purchases for The Vilter Manufacturing Company, I am happy to state that we find Summerill Tubing more uniform in diameter, in wall thickness and in length than any tube with which we are familiar. Summerill also consistently comes to us with a high quality finish and exceptional appearance."

"Manufacturing refrigeration equipment, air conditioning systems, heat exchangers and ice producing machinery naturally makes tubing a major item with us. And because of this importance, our Engineering and Design men, in conjunction with Production and Purchasing, spend unlimited time specifying, selecting and testing tubing."

"We build thousands of tube bundles similar to the one illustrated above, and using uniform Summerill Tubing means there is no need to selectively ream and re-ream each hole in the tube sheet to fit an individual tube. A Summerill Tube is also seated with one rolling operation and a single size of tool. There is added significance here if you count the 136 holes in this typical sheet. Repeating any of the reaming or seating passes immediately multiplies into a serious cost problem."

"Summerill Tubing is our recommendation because we have found a difference in the degree of uniformity in condenser tubes."

L. E. LOOS

There is little we would add to Mr. Loos' report on the dollar-and-cents-importance of specifying quality steel tubing by the name . . . SUMMERILL. All Summerill Tubing is produced under the meticulous supervision of our metallurgical laboratories.

There is a complete range of sizes of Summerill carbon and alloy tubing to meet your most demanding specifications. Be the person responsible for a step that can effect major cuts in production costs for your firm. Write for complete information on Summerill Seamless Steel Tubing . . . today.

Summerill Tubing Company Division-Columbia Steel & Shafting Co.

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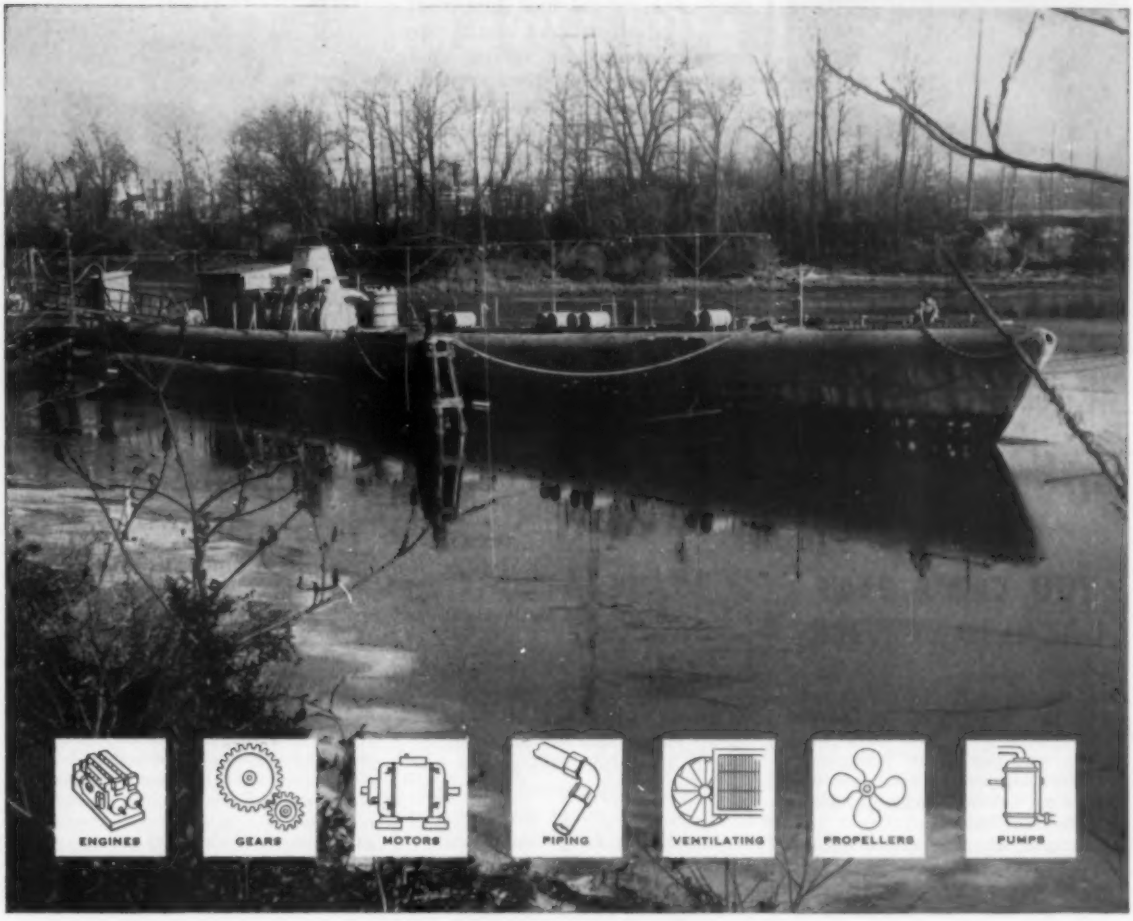
BRUSH...*offers complete systems for noise or vibration measurement*

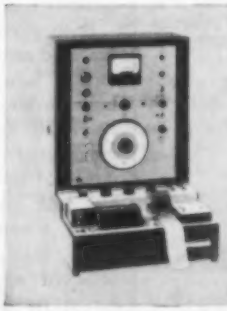


Floating laboratory gets facts on noise to make machinery quieter

In the Navy's experience, a noisy submarine is a dead submarine. Thus, the U. S. Naval Engineering Experimental Station has moored this sub in a quiet spot—and uses it as a test laboratory for noise reduction of machinery and other shipboard equipment.

By recording noise on a Spectrum Recorder, Navy technicians save days of engineering time with automatic analysis and recording of noise amplitude versus frequency. In addition to providing excellent frequency definition, this easy-to-use equipment furnishes a permanent chart record.

For complete information or application assistance on the integrated line of Brush-B & K instruments for sound and vibration measurement systems call your Brush representative, or write Brush Electronics Company.



Third-Octave Spectrum Recorder
key instrument in a complete line for noise and vibration measurements.

For information write Dept. L-10.

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YOU CAN'T BEAT GARRETT SERVICE

I'm not a wise guy, but I do know about the service these Garrett plants give you. Seems hard to believe. Those fellows bend over backwards to help you out in an emergency. And their regular service means you always get deliveries when promised ... sometimes before.

Of course, when it comes to quality they are tops on lock washers, flat washers, spring washers, hose clamps, stampings and assemblies. They have three plants equipped with the most modern high-speed automatic machinery to turn out billions of parts to exact specification . . . complete heat treating, plating and finishing facilities. If you don't believe me, next time send your order into Garrett. You'll see why their customers say YOU CAN'T BEAT GARRETT.

LOCK WASHERS
FLAT WASHERS
HOSE CLAMPS
STAMPINGS

Manufactured by

GEORGE K. GARRETT CO., Inc.
Philadelphia 34, Pa.

Garrett
OF PHILADELPHIA

effect of oxide and flux entrapment upon bond strength of several tin-zinc alloys; effects of tin-zinc ratio upon surface alloying, bond strength, corrosion resistance; effects of impurities such as iron, copper, lead on bonding characteristics, bond strength; microstructure of tin-zinc alloys with and without impurities; variation of bond strength wth soldering method; relation of variation of bond strength with soldering method; relation of EMF of various tin-zinc alloys to bonding characteristics and properties of soldered joints; commercial methods of manufacture of tin-zinc solders; cost, availability and ease of application considerations important to the selection of commercial tin-zinc solders; examples of various applications of tin-zinc solders on aluminum and aluminum alloys.

Abstracted from "Ultrasonic Welding," by J. B. Jones, Aeroprojects, Inc., and J. J. Powers, Jr., Pitman-Dunn Laboratories.

Solid state bonding has been achieved with both similar and dissimilar metals by the introduction of elastic vibratory energy into the metals in the area to be joined. This process may be accomplished without the application of heat except that which is associated with dissipation of the vibratory energy. It is immediately applicable in joining foil and thin sheet to very thin or massive members.

The power source and the presently utilized transducer-coupling system is described. The controlling parameters of power, vibratory energy, exposure time, and static clamping force are presented.

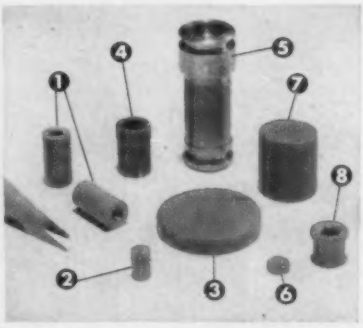
Both strength and deformation of the weld zone are compared to characteristic values incident to ordinary high-pressure welding and resistance spotwelds for certain metals. The same order of strength has been obtained as with these older techniques but with lower deformation. Representative photomicrographs of characteristic solid state metallurgical bonds achieved with this process between various metals are presented.

Abstracted from "The Significance of Fatigue Data in Pressure Vessel Design," by T. J. Dolan, University of Illinois.

In general, the types of surface defects, notches and abruptness of

(Continued on page 392)

FILTRATION NEWS



Filter to 900°F... anywhere!

PORO-KLEAN gives designer new freedom in filtering hot, hi-pressure fluids

"Versatile" is the word for Cuno's PORO-KLEAN filters when it comes to providing 3-30 micron filtration in hot spots and tight places!

In a tremendous variety of sizes and shapes, these new porous stainless steel filters are everywhere pushing back the temperature and pressure frontiers in micronic filtration. The reason: PORO-KLEAN's unique combination of physical properties. Its high strength, exceptional heat and corrosion resistance and adaptability to a wide variety of shapes makes it easy to apply both in industrial processing and in compact aircraft and missile hydraulic systems.

For instance take the tiny preformed shapes shown above. They are: cylinder (1), cup (2) and cup with lip (4)—all used to protect micro-finished aircraft hydraulic servo valves; disc (3) for oil filter, cylinder (5) with brazed-on seat for hydraulic O-ring; disc (6) for gas-turbine fuel-oil nozzle; cup (7) and (8) for diesel fuel-oil nozzle.

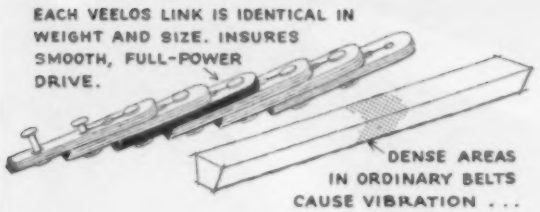
And, for the big jobs, you can get single or multiple PORO-KLEAN units like the 54-inch element (below, right). It's designed to filter synthetic polymer in a chemical plant with 1500 psi pressure drop and operation at 550°F.

If you have a tough filter problem, get all the details on Cuno PORO-KLEAN. You can be sure it will fit into your design. Write: The Cuno Engineering Corporation, 20-10 South Vine Street, Meriden, Connecticut. 6.2

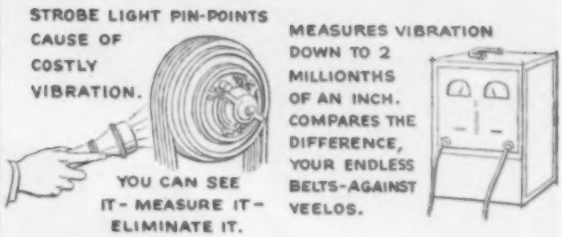
CUNO ENGINEERED FILTRATION

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge)
FLO-KLEAN (wire-wound) • PORO-KLEAN (porous stainless steel)

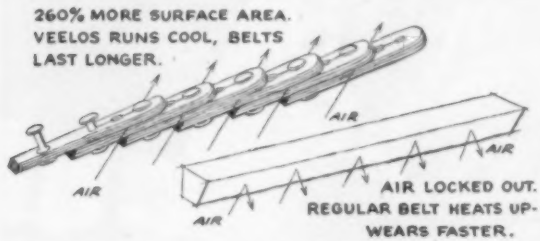
Six Reasons Why Veelos Adjustable V-Belts Are Better For Your Drives!


EACH VEELOS LINK IS IDENTICAL IN WEIGHT AND SIZE. INSURES SMOOTH, FULL-POWER DRIVE.
DENSE AREAS IN ORDINARY BELTS CAUSE VIBRATION . . . MACHINE WEAR

1. Balanced construction of Veelos Belts assures you faster, cleaner work, less rejects . . . less bearing wear. Each link and stud is identical in size and weight. Ordinary belts have varying spots of density which cause excess vibration—chatter marks, machine wear.


STROBE LIGHT PIN-POINTS CAUSE OF COSTLY VIBRATION.
YOU CAN SEE IT - MEASURE IT - ELIMINATE IT.
MEASURES VIBRATION DOWN TO 2 MILLIONTHS OF AN INCH. COMPARES THE DIFFERENCE, YOUR ENDLESS BELTS-AGAINST VEELOS.

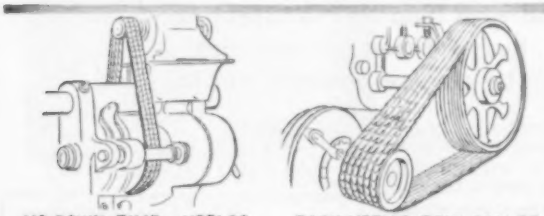
2. Electronic proof—up to 90% less vibration! With a vibration analyzer, you see, on your own machine, how Veelos belts decrease vibration up to 90% over any belt you're now using. This amazing Veelos test pin-points the belt that has the "invisible shakes."



3. Cooler running—long life! Veelos breathes! Constant circulation of air keeps Veelos running smooth. Regular V-belts have no chance to cool, heat builds up from the inside . . . causes slippage, wastes power, heats bearings, reduces belt life.

AREA CONTACT
POINT CONTACT
PERFECT VEELOS FIT. EXTRA THICKNESS AND MACHINE-CUT SIDES PREVENT BOTTOMING. MEAN CONSTANT POWER.
POWERLESS POINT CONTACT OF ORDINARY V-BELT. BULGES, SLIPS, CAUSES UNEVEN SHEAVE WEAR.

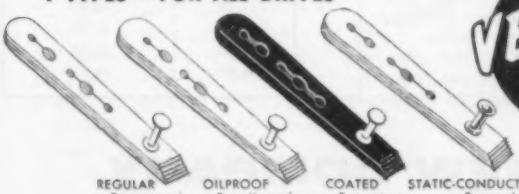
4. Greater flexibility reduces slippage! Sectional construction, beveled links allow greater flexibility, longer belt life. Each link moves around sheave independently and maintains full contact, constantly. Full area contact allows shorter centers, smaller sheaves.


NO DOWN-TIME. VEELOS FITS ANY DRIVE - WITHOUT DISMANTLING.
EACH VEELOS BELT CAN BE ADJUSTED - NO NEED FOR EXPENSIVE MATCHED SETS.

5. Simple installation "knocks out" down-time! Saves up to 50% installation time on outboard bearing drives, more when belt length isn't in stock. No resetting, tilting or moving motors. Veelos can be made any length, can be changed by adding or removing links.

6. Veelos won't stretch any more than ordinary endless V-belts when it is properly installed. *Remember—measure Veelos 1" short per foot and roll on drive as tightly as possible.* With the first few revolutions Veelos studs accept a permanent set into the sections they connect.

4 TYPES — FOR ALL DRIVES


REGULAR For general service
OILPROOF For oily and hot drives
COATED For wet or oily drives
STATIC-CONDUCTING For explosive atmosphere

VEELOS THE BALANCED LINK V-BELT

Known as Veelink outside U.S.A.

For all sizes and types of drives. Double-V available for serpentine drives.

Write for free Veelos Data Book or Veelos Vibration Demonstration to:

MANHEIM

Manufacturing & Belting Co.
407 Stiegel St., Manheim, Pa.

"Industrial Belt Specialists Since 1911"

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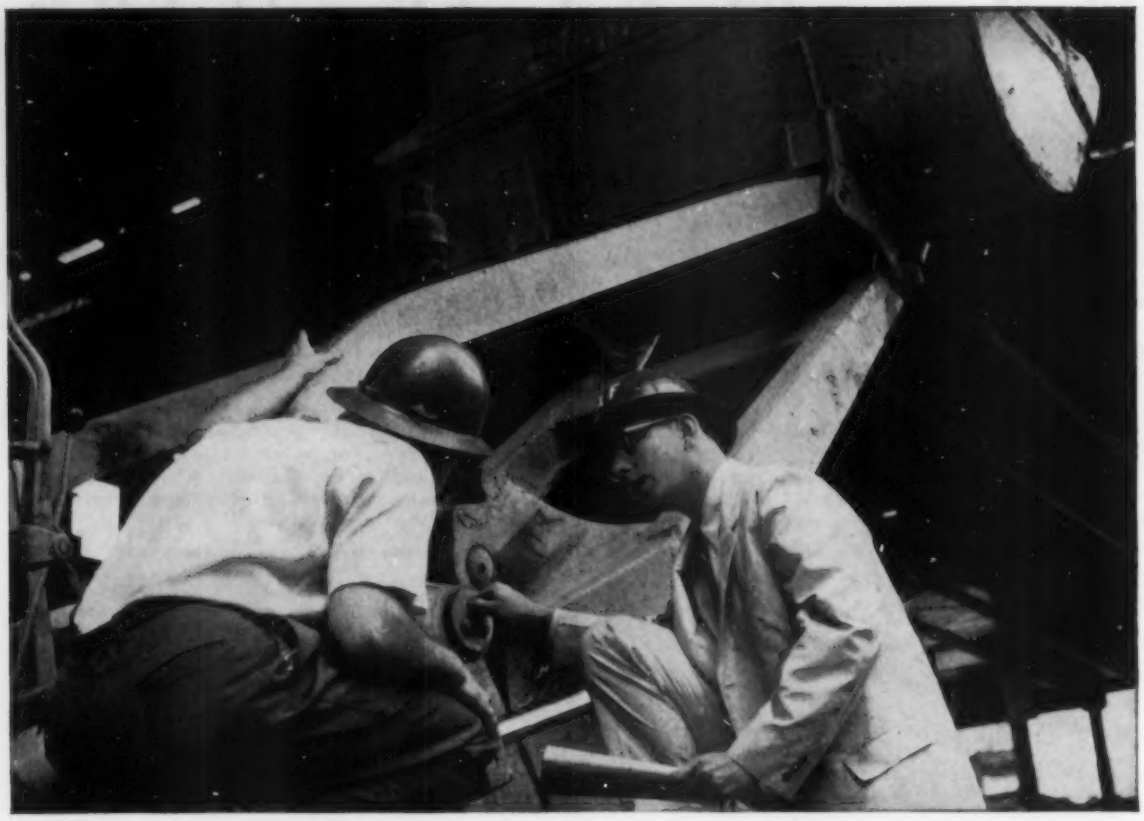

Why the trend to heat-treated cap screws in the heavy equipment industry?

Chicago Screw engineers worked with leading manufacturers to develop the high-strength, heat-treated screws that take more punishment and greatly reduce fastener costs

Strength, and the ability to withstand severe punishment, are prime requirements for fasteners used in heavy equipment. As a leading fastener source for most of the top manufacturers of heavy equipment, CHICAGO SCREW conducts a thorough research and development program aimed at steadily improving fastener performance.

A major result of this program is the development of the CHICAGO *carbon-restored* heat-treated cap screw, now replacing bright-finish fasteners for most heavy equipment applications. Design engineers have found the far greater tensile strength of the heat-treated fastener (see chart) gives a better fastening with fewer—or smaller—screws. This means less weight . . . and a considerable reduction in fastener costs.

In addition to greater strength, CHICAGO heat-treated cap screws prove far superior in withstanding fatigue, wear, shock and vibration. This is because a major cause of fastener failure—a surface layer of soft, decarburized steel—is eliminated by our unique Carbon Restoration process. Vital surface carbon is restored in a scientifically controlled process during final heat-treating, producing a fastener that's uniformly hard from core to surface.

Our engineers will be glad to advise you on designing to best take advantage of heat-treated cap screws. For complete information on cost savings you can get in your products . . . and a detailed version of the condensed tensile strength chart at right . . . drop a line to our Standard Products Division.

HOW TENSILE STRENGTH COMPARES

Diameter (Coarse Thread)	Bright Cap Screws Tensile Strength (Pounds)	Heat-Treated Cap Screws SAE Grade 5 Tensile Strength (Pounds)
¼	2,150	3,810
5/16	3,550	6,270
⅜	5,250	9,280
7/16	7,200	12,720
½	9,650	17,000
9/16	12,400	21,800
⅝	15,400	27,070
¾	21,400	40,100
⅞	29,500	53,040
1	38,700	69,590

THE CHICAGO SCREW COMPANY

DIVISION OF STANDARD SCREW COMPANY • ESTABLISHED 1872
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CORNING GLASS BULLETIN

FOR PRODUCT DESIGNERS

Microwaves in the kitchen

Tappan's latest electronic range lets you cook a 5-pound roast in 30 minutes, bake a potato in 4, broil bacon in 1½, heat a jar of baby food in 45 seconds.

Key to this microwave magic is a magnetron supplied by Raytheon. It generates waves of 2450 megacycles, a frequency that requires licensing by the Federal Communications Commission.

These waves do the cooking. They are fed into the oven cavity by a guide mounted at the top and properly diffused by a slowly revolving fan and a sheet of glass.

This glass, as you might imagine, is no ordinary piece of window pane. It has to pass the high-frequency waves and help in their even distribution. It also must protect the electronic elements and fan from hot, spattering grease.

Handling the task nicely is Corning's VYCOR brand glass No. 7900, one of a group of 96% silica glasses exhibiting some quite unusual performance characteristics.

Tubing below VYCOR glass shield (arrow) is an infrared unit to give a pleasant "browning" effect to food.

For example, you can heat an object made of No. 7900 glass to 900° C., then plunge it into ice water. You'll get *no* cracking, crazing, breaking, or changing in shape or structure even after such terrific thermal shocks.

Continuous use at 900° C. is standard operation; and intermittent use to 1200° C. is both possible and practical.

VYCOR brand glass also does a fine job of transmitting ultraviolet at wave lengths of 365 millimicrons and higher, and short-wave infrared up to 3.5 microns.

Details on seven of the VYCOR brand glasses (including facts on manufacturing, physical properties, uses and forms) are summed up in B-91: "VYCOR brand Industrial Glassware by Corning." A copy awaits your request.

Lachrymal lesson

Legend has it that ancient Romans grieving their departed collected their tears in small vases and buried the vases with the deceased.

Such vases go back to the Rome of about 300 A.D. Yet, despite this antiquity, so many are *still* in such perfect shape that a tourist can own one for the outlay of a mere 50 cents.

Lesson? Oh, yes, —these long-lasting vessels for lachrymal liquid were made of *glass*. And glass, as made *today*, offers the designer a host of useful qualities, in addition to durability.

Take as a starter, PYREX brand glass No. 7740. It's the choice of those whose products must cope with corrosive environments, thermal shock, and rough handling in general.

Among the literally thousands of useful items fashioned from this particular Corning glass you'll find precision labware; piping for the food, chemical and drug industries; broiler shields; oven windows; oven cooking ware; dental and medical products; vapor chambers; coffee makers and servers; and sundry lamp globes.

No. 7740 is just *one* of a wide array of glasses by Corning available in commercial quantities . . . which brings us to a standing offer:

You can tap the data files on some 50,000-odd formulas for glass in quest of an answer to your materials problems. What we've learned about the advantages (and limitations) of glass we'd like to share with you.

Or, if more background data on what you can do with today's *engineered* glasses seems in order, send for any or all of the free literature listed in the coupon.

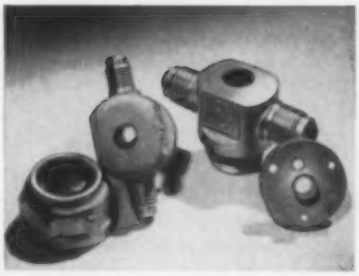
Look, no gasket!

Troubles—that's what most of us have come to expect with sight glasses used in pipelines or other strategic locations.

Causes are not hard to pinpoint—innocent tampering, heat and vibration that cause failure in soldered joints, various forces that result in gaskets degenerating.

'Til now most of us have quietly accepted the inevitable disruptions. But, there's no need to any longer.

Working with a prominent supplier of refrigeration equipment, we've come up with a real innovation—a gasketless, solderless, sight-glass assembly.



Glass fused directly to metal provides unusually rugged service in these sight glass assemblies.

In this new Corning development, the glass and metal are fused directly together. Result? A hermetically-sealed, tamperproof arrangement that stands up to moderate heats and high pressures.

A number of variations are available, with diameters ranging from $\frac{3}{16}$" to 1", with glasses from $\frac{1}{16}$" to $\frac{1}{4}$" thick.

Typical performance—$\frac{3}{8}$" diameter and a $\frac{1}{8}$"-thick glass withstood pressures in excess of 5,000 p.s.i.

If you need to see what goes on in a closed system, why not look into these windows?

Corning means research in Glass

CORNING GLASS WORKS, 51-10 Crystal Street, Corning, N. Y.

Please send me the following material: Bulletin B-91, "VYCOR brand Industrial Glassware by Corning" ☐; Bulletin IZ-1, "Glass . . . its increasing importance in product design" ☐; Bulletin B-84, "Manufacturing and Design of Commercial Glass" ☐; Illustrated booklet, "Glass and You" ☐; Information on sight glasses ☐.

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The MB Model C-25HB (shown) is rated at 5000 pounds peak force. Its table assembly is unusually stiff to reduce resonances yet weighs only 75 pounds. Axial resonance lies well over 2000 cps operating range.

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If you have any questions on vibration testing at all, come to a leading authority on the subject . . . the MB engineering staff.

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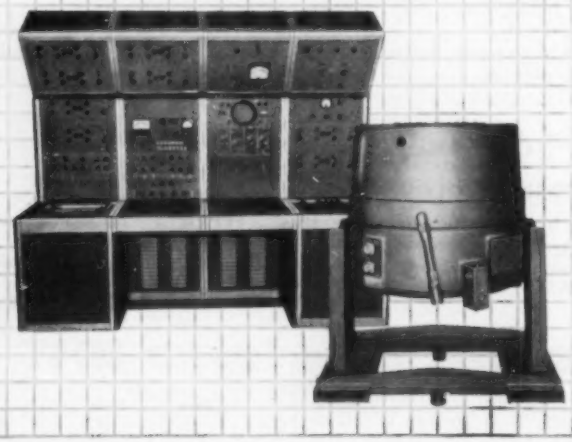


changes in contour, determine the localized stresses from which progressive fractures initiate, if loading is repeated many times. Vessels intended for long life and which are subjected to large variations in stress (due to pressure variations or thermal fluctuations) should be designed for adequate fatigue resistance by eliminating excessive stress raisers and careful control of fabrication and operating procedures. Recent data obtained from studies sponsored by the Pressure Vessel Research Committee are reviewed from the viewpoint of their inferences in use of high strength steels and increased design stresses. Difficulties of interpretation of laboratory fatigue data for quantitative design of full-sized structures are related to the statistical nature of fatigue and the many factors affecting fatigue strength. Elimination of severe stress raisers by improvement of design details is more effective than material selection in insuring safety.

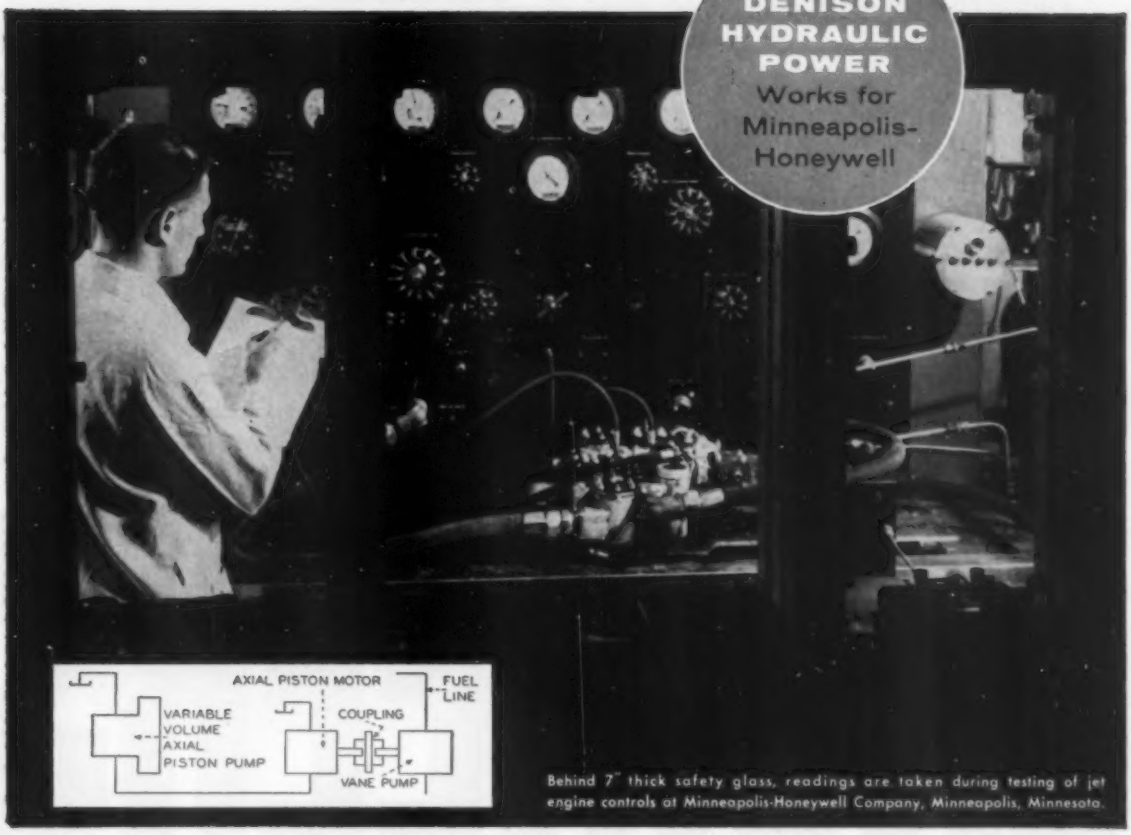
Abstracted from "Properties of Arc-Welded Joints Between Aluminum and Stainless Steel," by M. A. Miller and E. W. Mason, Aluminum Co. of America.

Tensile, bursting and fatigue strengths of tungsten arc welded tube joints between 3004-0 tubes and aluminum coated, type 304 stainless steel tubes approximate the typical strengths of 3004-0 tube without a joint. Shear strengths of tungsten are welded tube joints between 6061-T6 and aluminum coated, type 304 stainless steel, made with 4043 filler metal, were found to be only a little lower than the typical shear strength of cast 43 alloy.

A consideration of the effect of post-heating on the shear strength of aluminum-steel joints made in various ways indicates that tube joints might operate safely at temperatures up to 500 F for long periods of time without loss of shear strength. On the basis of results on thermal shock cycling tests, between room temperature and 500 F, on brazed joints between 6063 alloy and aluminum coated, Type 347 stainless steel, it may be assumed that arc weld joints between aluminum tubes and aluminum coated stainless steel tubes will be able to withstand this type of shock without effect.

Limited corrosion data suggest that aluminum tube-stainless steel tube joints will have an adequate resistance in many environments.

How **DENISON HYDRAULIC POWER** Works for Minneapolis-Honeywell



Behind 7" thick safety glass, readings are taken during testing of jet engine controls at Minneapolis-Honeywell Company, Minneapolis, Minnesota.

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Denison Variable Volume Axial Piston Pump remote controlled.

A unique electronic system developed by Minneapolis-Honeywell to pre-test jet engine controls now eliminates the cost of building and operating a special engine test cell. The system actually produces a more accurate record of performance than would be possible if the actual engine were used.

The system works this way. An analog computer takes the place of the jet engine. Performance data and other characteristics are received from the manufacturer. These are then simulated on the computer and reproduced as electrical signals, which, in turn, run the engine controls.

To provide dependable muscle power for this control system, Minneapolis-Honeywell relies on Denison hydraulic pumps and motors. The key unit, a Denison Variable-Volume Axial Piston Pump is the prime mover for a Denison axial piston motor that in turn powers a Denison vane pump to deliver jet fuel.

Denison hydraulic equipment is today serving all industries by cutting operating costs, speeding production, and improving reliability. Let a Denison field engineer show you how you can benefit from Denison's hydraulic experience. Write Denison Engineering Division, American Brake Shoe Co., 1194 Dublin Road, Columbus 16, Ohio.

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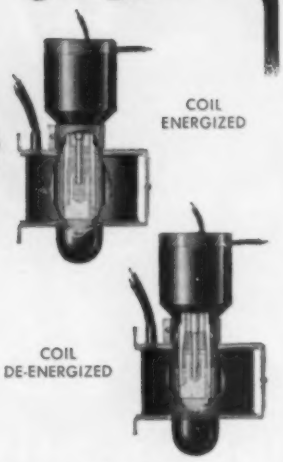

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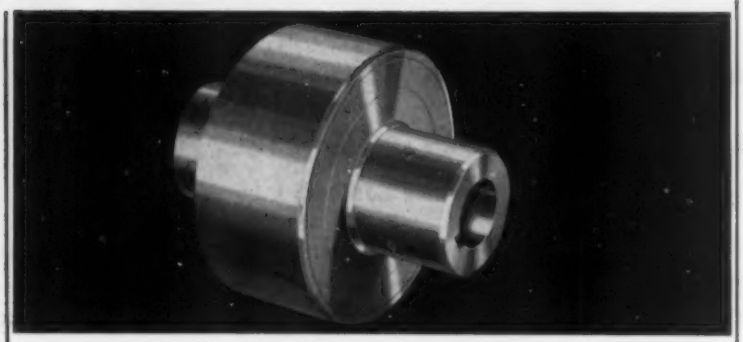

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Better motor efficiency, better power factor

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NEW BOOKS

Effects of Environment On Embrittlement of Metals At High Temperatures

ASTM Technical Publication No. 171, paperbound, 9 x 6 in. 120 pp. *Published by American Society for Testing Materials*, 1916 Race St., *Philadelphia* 3, *Pa.* $2.75.

Since most of the creep and creep-rupture tests from which design data on high-temperature alloys can be obtained are carried out in normal atmospheres and since most high-temperature materials are used in atmospheres of water vapor or products of combustion, the design engineer must always be concerned with the effects of the environment upon the creep rate and the ductility of the material that he uses. This symposium includes six papers on oxidation and surface effects, and represents the status of the problem of environment at the present time.

Mathematical Theory Of Elasticity

I. S. Sokolnikoff. *Professor, University of California.* 6 x 9 *in.*, 476 pp. *Published by McGraw-Hill Book Co.*, 330 W. 42 St., *New York* 36, *N. Y.* $9.50.

The theory of elasticity, in its broad aspects, deals with the behavior of substances that possess the property of recovering their size and shape when the forces producing deformations are removed. In common with other branches of applied mathematics, the growth of this theory proceeded from a synthesis of special ideas and techniques devised to solve definite problems. This resulted in a patchwork of theories treating isolated classes of problems, determined largely by the geometry of bodies under consideration. The embedding of such diverse theories in a unified structure, and the construction of the analytical tools for calculating stresses and deformations in a strained elastic body, are

(Continued on page 401)

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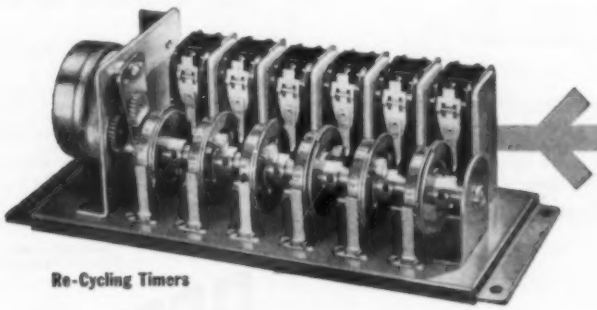

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among the dominant concerns of the mathematical theory of elasticity.

This book attempts to present several aspects of the theory of elasticity from a unified point of view and to indicate, along with the familiar methods of solution of the two-dimensional problems.

The present edition differs from its predecessor by extensive additions and changes. Most of the material appearing in the last three chapters has no counterpart in the first edition. Also included are selected references to give an accurate picture of the present state of the topics treated in this book.

The first three chapters contain a comprehensive treatment of the underlying theory of mechanics of deformable media. Chapter 4 gives an up-to-date treatment of extension, torsion and flexure of beams, including the deformation of homogeneous and non-homogeneous beams by loads distributed on their lateral surfaces. Chapter 5 is concerned with two important categories of plane problems of elasticity. Chapter 6 deals with three-dimensional problems and contains a formulation of thermoelastic problems and an introductory account of the theory of vibrations and propagation of waves in elastic media. Chapter 7 contains a treatment of the energy theorems in elasticity and their bearing on the variational methods of solution of elastostatic problems.

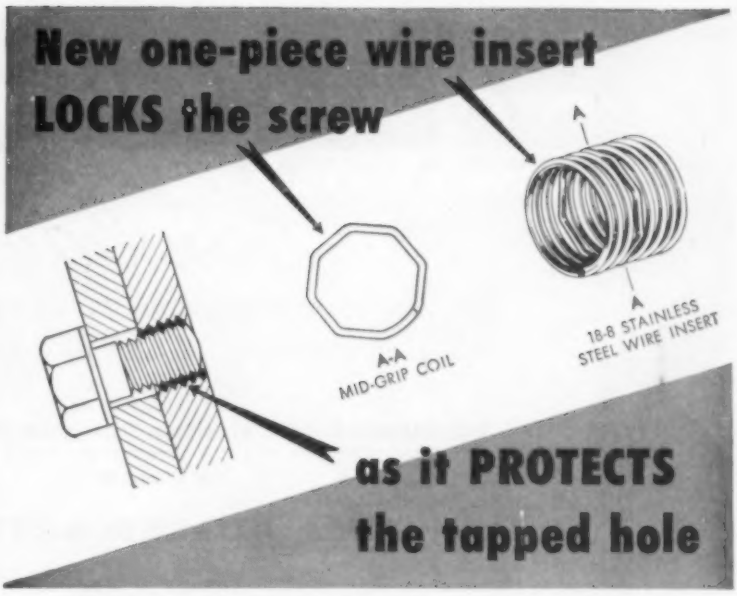
Zirconium— Technology and Economics

Report of Industrial Committee on Reactor Materials. 8½ x 11 *in.*, 113 *pp. Published by the Atomic Industrial Forum, Inc.*, 260 *Madison Ave., New York* 16, *N. Y.* $3.

The Atomic Industrial Forum, Inc. is a non-profit membership organization whose purposes include: (1) advancing the development of atomic energy within the free-enterprise framework; (2) providing a forum for the resolution of problems relating to atomic energy; (3) promoting wider understanding of the great potential of atomic energy; (4) encouraging research and development in the field.

This report is a compilation of papers and discussions prepared by

(Continued on page 405)



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Regular *Heli-Coil* Inserts (no locking action) put corrosion-proof, strip-proof stainless steel threads in soft materials . . . permit smaller, fewer fastenings, lighter weight, reduced cost.

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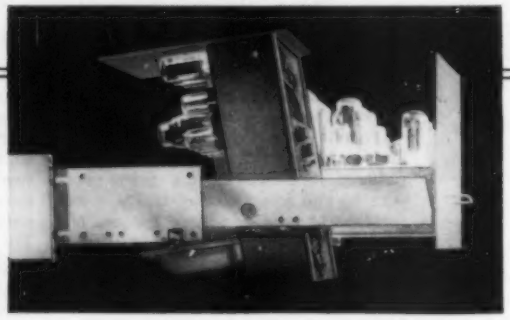
(fits RETMA *rack hole spacing)*



The Grant 3400 Thinslide requires only 19/64" space per side—installs readily in standard racks and cabinets. Allows instant access to chassis measuring from 10" to 16" deep. Tilts through 100° for under-chassis servicing. Positive lock in "out" position. Lock has finger-tip release for instant return or removal of chassis. Eight hardened steel rollers carry the rated load of 100 lbs. smoothly and easily—durability insures frictionless rolling for thousands of cycles of use.

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The Grant 3400 is a versatile slide, suited for use in your *product*, in *plant equipment*, *prototype* and *breadboard* work, and in *production line or field test equipment*. Very moderate cost allows a wide range of applications in original equipment.

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MORE EFFICIENT DESIGN, IMPORTANT SAVINGS, SIMPLIFIED ASSEMBLY, BETTER APPEARANCE

These are some of the many benefits reported by Design Engineers who have adopted TRU-LAY PUSH-PULLS for remote control operations on literally hundreds of products

Here are typical comments recently received from equipment manufacturers whose machines or implements are equipped with these accurate and dependable remote controls:

Saves Time, Labor and Material
"The use of your flexible Push-Pulls saves us a great deal of time, labor and material. The old linkages frequently required much planning in both engineering and shop which is not required now. On some of our equipment we use Push-Pulls from 10 to 30 feet in length. They operate clutch controls on the Main Power Unit, Feed Conveyors and Delivery Conveyors."

Greater Flexibility of Design
"The principal advantage of Tru-Lay Push-Pulls in our application is that they permit flexibility in locating the control valve in relation to the operator's position."

Cost Less to Install
"Tru-Lay Push-Pulls are easier and less expensive to install than linkages for remote control of power take-off, brake and clutch. Better appearance, too."

Simple and Neat
"For several models of farm tractors, we selected your controls for their simplicity and neatness of application as governor controls."

Solution to Tough Problem
"Can be installed where straight rods are impossible . . . for Remote Control of transmissions, brakes and clutches."

Eliminates Maintenance
"Simple operation and elimination of maintenance problem are the major advantages in using your Push-Pulls."

Reduces Number of Parts
"Your Push-Pulls have eliminated links, radius rods and other lost-motion devices for remote control of hydraulic valves."

Provide ACCURATE Control
"Tru-Lay Push-Pull control cables provide minimum back-lash, even in installations up to 30 feet in length, because the cable is designed to close tolerances with minimum drag and lost motion."

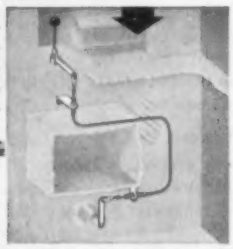
• • •

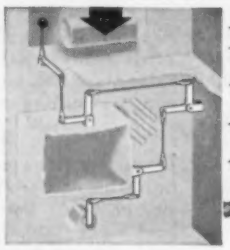
TRU-LAY PUSH-PULLS are "Solid as a rod but *Flexible* as a wire rope." This flexibility makes it possible to snake around obstructions . . . permits the ideal arrangement of all elements of remote controls.

***Advantages** of Tru-Lay Push-Pull flexibility and simplicity are pictured below—*

TRU-LAY PUSH-PULL — **MECHANICAL LINKAGES**

Simple
One Moving Part
Life-Time Service
Life-Time Accuracy
Low over-all Cost
Noiseless





Complex
Many Parts
Many Points of Wear
Increasing Back-Lash
Loss of Accuracy
Vibration
Rattles

Construction Equipment and **Farm Implements** provide good examples of the wide-spread use of these accurate, simple and dependable Push-Pulls. On Power Shovels, Winches, Graders, Road Oilers, Dump Trucks, Snow Plows, Engine-driven Pumps, Crushers, Tractors, Combines, Corn Pickers, Corn Row Sprayers, Corn Detasslers, Orchard Sprayers, Power-driven Tree Trimmers, Tobacco Picking Machines and others . . .

TRU-LAY PUSH-PULLS are operating unfailingly for the remote control of Hydraulic and Air Valves, Brakes, Clutches, Transmissions, Throttles, Chokes, Governors, Power Take-Offs, Spray Nozzles, Vent Directional Fins and on many other applications.

ACCO *Our DATA FILE will answer all further questions*

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AMERICAN CHAIN & CABLE

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There is No Worry about Failures or Maintenance Costs with TRU-LAY Push-Pull Remote Controls

Long Life is a matter of record. We have never heard of a Tru-Lay Flexible Push-Pull Control wearing out in normal service. Failures, that sometimes harass users of more complex controls, are eliminated by the use of these simple, positive-action controls.

Dependable Operation of these controls is a certainty, even under the most adverse conditions . . . HOT as jet engines (note: Tru-Lay Push-Pulls are actually performing on hot jet applications) . . . COLD to 70° F below zero . . . SOAKIN' WET . . . ABRASIVE . . . or just plain TOUGH.

Freedom from Trouble is assured because of such features as . . . full protection of the inner, working member by the tough flexible conduit . . . lubrication of the inner, working member *for life* during assembly . . . seals that keep moisture, dust and other foreign matter out of the unit . . . cold swaging of fittings that makes them integral parts of the control unit.

Accuracy is inherent in the basic design of Tru-Lay Push-Pulls. They are precision products, not gadgets.

Capacity ranges from light jobs up to jobs of 1,000 lbs. input. These Push-Pulls will handle jobs 150 feet or more from the control point.

"Solid as a rod, Flexible as a wire rope" aptly describes Tru-Lay Push-Pull Controls. This flexibility provides positive, remote action whether anchorages are fixed or movable . . . it damps out noise and vibration . . . it greatly simplifies installation of controls by reducing the number of working parts and by making it possible to snake around obstructions.

Adaptability to all sorts of mechanical situations explains, in large measure, the wide-spread application of Tru-Lay Push-Pulls. Standard anchorages, fittings and heads have been designed that meet requirements on approximately 80% of the installations. Simple modifications of these standards, or minor changes in your own design, cover almost every special situation. Our engineers have the know-how on such matters, and will work with you.

For Further Information—The DATA FILE pictured at the left contains six booklets and bulletins that will answer any further questions you may have about this versatile and dependable tool. It is quite likely that this material will point the way to a simplified solution of your remote control design problems. Write for a copy.

the Forum for industrial use. Covered are a broad range of topics such as chemistry and reduction, melting and casting, rolling and forging, drawing and extrusion, powder metallurgy, physical properties, corrosion behavior, alloys, new material supply, refined metal supply, commercial products, AEC requirements and industrial outlook. The report provides an excellent up-to-date introduction to zirconium technology. It is the intent of the Forum to follow this conference with a symposium on the effects of radiation on the properties of materials.

Handbook of Welded Steel Tubing

9 x 11 *in.*, 267 pp. *Published by Formed Steel Tube Institute, Inc., 850-52 Hanna Building, Cleveland 15, Ohio.* $20.

This handbook has been prepared in two parts: carbon steel tubing and stainless steel tubing. Both sections present a wealth of information on manufacturing methods for welded tubing, shapes available, tolerances, mechanical properties, fabrication procedures and applications. A detailed glossary is appended, together with a useful design data section.

Introduction to Numerical Analysis

F. B. Hildebrand, *Assoc. Prof. of Mathematics, Massachusetts Institute of Technology.* 6 x 9 *in.*, 511 *pp. Published by the McGraw-Hill Book Co., Inc., 330 West 42 St., New York 36, N. Y.* $8.50.

An introductory treatment of the fundamental processes of numerical analysis which is compatible with the expansion of the field brought about by the development of the modern high-speed calculating devices. At the same time, account is taken of the fact that very substantial amounts of computation will continue to be effected by desk calculators (and by hand or slide-rule), and that familiarity with computation on a desk calculator is a desirable preliminary to large-scale computation in any case.

This work gives a substantial grounding in the basic operations of

(Continued on page 409)

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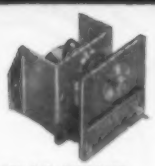

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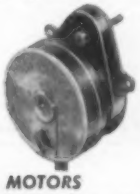

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Cross Wire Welding

How to Use It to Improve Product Design and Quality

What is Cross Wire Welding

Cross wire welding is a method of fastening wires or rods to one another at the point where the wires cross. It is a process that lends itself efficiently and economically to electric resistance welding techniques. In the extremely competitive wire goods field it is essential.

Done in this manner, a cross wire weld is a form of projection welding. The circumferential contour of the wire or rod itself causes the current to be localized at the point where the wires cross, generally at right angles.

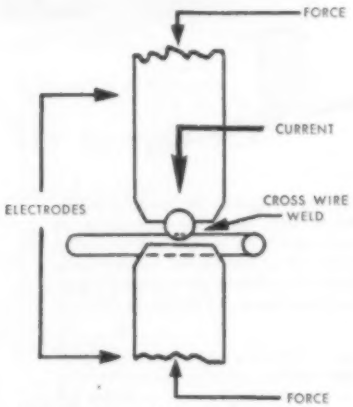

Fig. 1—Cross wire welding process.

The electrode dies which contain the weldable material are connected to a high current, low voltage transformer. Sufficient heat to weld is generated within the parts by the resistance of the metal to the passage of electric current. An electrode pressure forges the heated parts together until the proper amount of weld "set down" has been obtained which gives the piece part its necessary strength.

The term "set down" is the degree to which the wires are pressed together and is measured in terms of percent of wire diameter. It is dependent upon the amounts of heat (current), electrode force, and weld time duration.

STRENGTH OF CROSS WIRE WELDS

(Using Sciaky equipment with suitable settings)

Wire Dia. (in.)	Strength in Pounds					
	Cold Drawn Low Carbon Steel			Hot Drawn Low Carbon Steel		
	15% Setdown	30% Setdown	50% Setdown	15% Setdown	30% Setdown	50% Setdown
1/16	450	500	550	350	400	450
1/8	975	1,125	1,250	750	850	900
1/4	3,700	4,200	4,400	2,800	3,000	3,100
3/8	6,700	8,350	8,800	6,200	6,800	7,200
1/2	12,200	13,600	14,600	11,500	12,400	13,000

Advantages of Cross Wire Welding

Cross wire resistance welding requires no additional metal, arcs, gas or flame. *The weld is within the materials themselves*—and is as strong, if not stronger, than the parent metals.

Fig. 2—Typical cross wire weld section of wire basket.

Appearance is also an important advantage. Cross wire welding is currently being done so efficiently with Sciaky resistance welding techniques that little evidence of the weld is visible in the finished product. The small amount of upset is smooth without splashes or burrs.

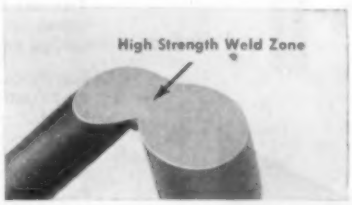

Fig. 3—Diagonal cross section of cross wire weld. Diameter of wires are 5/16" and 3/16"—cold drawn mild steel.

Many products that were not originally designed for resistance welding can easily be adapted with simple tooling. Costly jigs and fixtures can be eliminated too. The capacity of Sciaky patented Three Phase resistance welding equipment permits tooling ingenuity to accomplish a quantity of welds per welder stroke impossible with conventional single phase equipment.

When to Design for Cross Wire Welding

As a rule, this application is done in multiple welds wherever wires or rods must be fastened to each other. Wire mesh, baskets, wire wheel disks are typical examples. A cross wire welding chart has been prepared to indicate obtainable strengths of welds of cold-drawn and hot-drawn low carbon steel of the same diameter.

Write Today for Free Sciaky Literature

Start to build your data file on resistance welding today. Our "Resistance Welding at Work" publication, Vol. 3, No. 9, and Vol. 4, No. 1, contains case histories of Sciaky cross wire resistance welding techniques. Designers' Guide Bulletin 331 discusses other forms of resistance welding.

Describe your particular fastening problems on company letterhead and we will send suitable back and future issues of our "R.W.A.W." publication. All contain impressive examples of Sciaky's basic thinking—resistance welding techniques designed to put the profits back into manufacturing.

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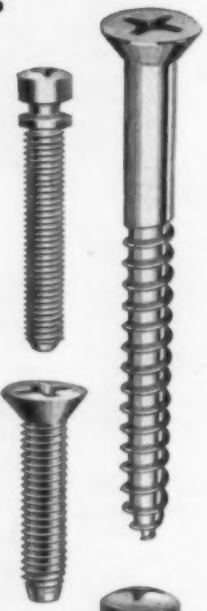

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The 440 Series – for supercritical applications An all stainless bellows valve with Teflon seat—⅛" to ½" pipe sizes. (Both 480 and 440 series have replaceable bellows assemblies.)

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computation, approximation, interpolation, numerical differentiation and integration, and numerical solution of equations, as well as applications to such processes as the smoothing of data, the numerical summation of series, and the numerical solution of ordinary differential equations.

Basically, the volume is designed to be used as a text for an introductory course in the field of numerical analysis. Its preparation was motivated by the belief that this course not only should exhibit techniques available for the various basic operations, but also should attempt to derive the relevant formulas in such a way that the underlying hypotheses are in evidence, that methods of generalization and modification are reasonably apparent, and that the problems of error analysis, convergence, and stability should be treated as adequately as time and preparation permit. There are problems associated with each section, ranging in nature from relatively routine calculations to analytical extension of the theory.

How to Find a Buyer For Your Invention

V. D. ANGERMAN, *Publisher.* 5¼ x 7¾ *in.*, 186 *pp. Published by Science and Machanics Publishing Company, 450 East Ohio St., Chicago 11, Illinois.* $2.95.

This book is a sales manual prepared for inventors; it gives sound, practical advice on the marketing of inventions, patented or unpatented.

In addition to giving the inventor details of 8 ways to sell an invention, this book lists the names and addresses of 140 manufacturers, with executives to contact, who buy inventions.

Electronics in Industry

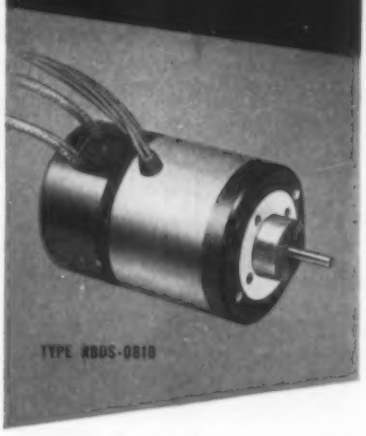
GEORGE M. CHUTE, *Prof. of Electrical Engineering, University of Detroit.* 6¼ x 9¼ *in.*, 431 *pp. Published by McGraw-Hill Book Co., Inc., 330 West 42 St., New York 36, N. Y.* $7.50.

This book presents the basic fundamentals of electronic devices in industry, and explains how these devices are used in practical circuits. The material in this second edition is arranged and supplemented so that it

(Continued on page 411)

HOLTZER -CABOT

D-C Miniature Servo-Motor



Holtzer-Cabot's Type 0810 has been used widely in gun fire control, radar navigation and radio tuning. Versatile and efficient, it features immediate response to minimum input signal. The armature is designed for continuous excitation from a 24 to 29 volt D.C. source through a 28 ohm series resistor. The field has two 10,000 ohm sections: one for CW and the other for CCW rotation. Full rated motor output is obtained by 6 ma. differential.

SPECIFICATIONS: Rating 0.3 oz. in., 6500 R.P.M., .002 H.P.; Diameter: 1⅝"; Field Current 6.0 Milliamps: Armature Current 0.4 amp; Duty Cycle: 4 reversals per minute; Altitude: 50,000 feet; Amb. Temperature: —65°C. to +72°C. Designed to meet MIL specs.

HOLTZER-CABOT ENGINEERING

NP

HOLTZER-CABOT MOTOR DIVISION
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AC SPEED CONTROL SYSTEMS

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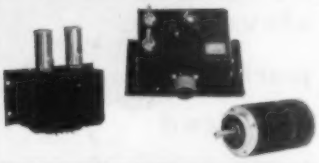
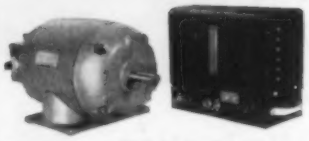


OR INDUSTRIAL—



APPLICATIONS

WacLine Power Systems provide the economical answer to speed control of AC motors under variable or constant-torque applications. Speed is infinitely adjustable over a wide range. Close regulation is readily accomplished even under varying torque. The WacLine system may be applied to single or multi-phase sources on any frequency from 50 to 1000 cycles. Special features such as Program Control, Voltage Signal Response or independent adjustment of forward and reverse speeds are available.

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Photographic Equipment—Medical Equipment.

may be used for a general or survey course by technical institutes or for university students of mechanical, chemical, civil, or aeronautical engineering; it may be used as a supplementary text in electrical engineering.

Details of communication circuits are not covered, except as they may have industrial application; uses of vapor or gas tubes are stressed. Several laboratory electronic instruments are discussed, as well as the many non-electronic devices often used in electronic equipment.

Tubes are in introduced in simple operating circuits to acquaint the reader with the purpose of electronic equipment while exploring the nature of the tubes themselves.

In this revision, recent designs of industrial controls are substituted; those for resistance welding are covered more completely. An added chapter on simple closed-loop systems gives a basic introduction to servos and the new field of automation. More questions are included for self study.

Fundamentals of Vibration Analysis

N. O. Myklestad, *Snr. Engrg. Specialist, AiResearch Mfg. Co. of Arizona.* 6 x 9 *in.*, 260 *pp. Published by the McGraw-Hill Book Co., Inc.*, 330 *West 42nd St., New York 36, N. Y.* $6.50.

This text emphasizes fundamentals and is primarily designed for a first course in vibration analysis at either the undergraduate or graduate level. In addition, it will be an appropriate text for training purposes in industrial organizations engaged in the manufacture of aircraft, engines, turbines, or any mobile equipment.

The objective of this book is to give the reader a thorough understanding of vibrations from a basic point of view rather than by presenting routine methods of analysis. Since only the classical method of analysis is used, every effort is made to develop the material in such a way that a clear picture of the phenomena involved is brought out while numerical and routine methods of analysis are reduced to a minimum. After the fundamentals have been mastered in this way, the reader will be able to

(Continued on page 413)

DURAMETALLIC Packings
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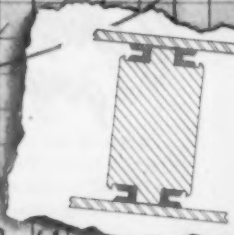

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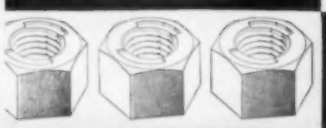

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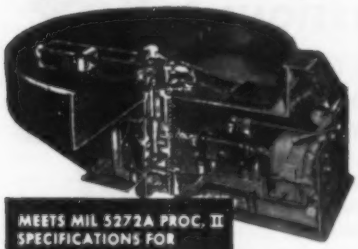

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D184	1 to 800	6 1-lb. objects	12"
E185	0.01 to 60	300 lbs.—30" cube	72"

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go on to study the numerous special tools developed for solving more complicated problems.

The book contains many new features of presentation such as a new proof of the orthogonality condition, introduction of the concept of damped modes of free vibration, new treatments of vibration instruments and balancing.

Numerous examples and problems aid the reader's understanding and demonstrate the applicability of the methods of analysis used in the text. The unusually large number of problems, many of which are answered in the back of the book, make this text useful to practicing engineers as a reference or for self instruction.

The Application of Plastics to Roller and Ball Bearings

A Report prepared for Research and Development Div., Detroit Arsenal. 9¼ x 11 in., 115 pp. Published by Kaydon Engineering Corp., McCracken St., Muskegon, Mich. $4.75.

The report covers in detail a project to determine the best types of plastics for use as rolling elements in heavy-duty turret or cupola bearings on combat vehicles. The project was found necessary since published technical data and mechanical properties have not been adequate enough for bearing design engineers to utilize plastics in ball and roller assemblies.

Although the report was compiled specifically to obtain data for combat vehicle manufacture, it contains much information of value to any company interested in plastic ball and roller bearings. The report covers complete data on all plastics tested, testing procedures used, testing evaluations, charts showing the comparative merits of plastic ball materials, bearing design data, and a number of graphs showing load vs deflection for different diameter balls made of various plastics. Cages or separators and lubricants for a turret bearing are also discussed.

Research brought out that compression molded melamines were found to be the best. From the many commercial plastics tested, Melmac #1077 and Bakelite BM 13080 were found to be most satisfactory from a

(Continued on page 415)

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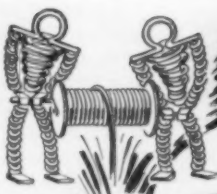

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standpoint of load, deflection, shock, chemical resistance and other properties. An empirical mathematical approach for determining capacity and deflection for ball and roller sizes to 1½-inch diameter or even larger was determined. It was found that these functions obeyed a variation of the Hertz bearing formulas.

To prove the reliability of the formulas, tests of several sized elements were made up to 1¼ inch diameter, which is thought to be the maximum size that may be used for turret bearings. Tests and formulas were not only completed for elements on a flat plate, but also for balls in a grooved race. It was found that plastic balls in a grooved race are preferred over rollers or balls on a flat plate for structural and capacity reasons.

Planning and Developing The Company Organization Structure

ERNEST DALE. 6 x 9 in., 232 pp. *Published by American Management Associatiaon, 330 West 42nd St., New York 36, N. Y.* $3.50—*AMA members;* $4.75—*non-members.*

The application of systematic methods to the conduct of business is one of the most striking developments of the present day. The successful pursuit of business activities is increasingly based on carefully developed plans and well-ordered arrangements. The body of knowledge, called organization, has become increasingly helpful in accomplishing the objectives of the enterprise.

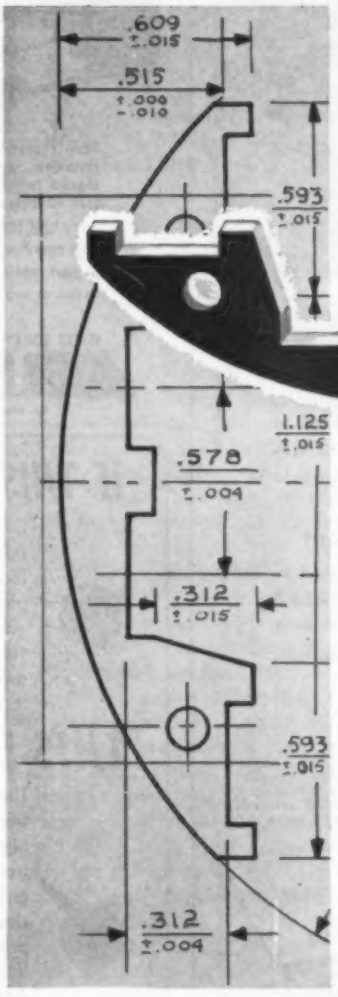
This book is an analysis of the development and change of the organization structure of the individual company. It is an attempt to combine the systematic thinking on this subject with the "rule of thumb" of practical experience. It essays an integration of the formal structure of the enterprise with the human forces that mold and are molded by it. Thus, it is designed to aid the practical man of affairs as well as the student of organization.

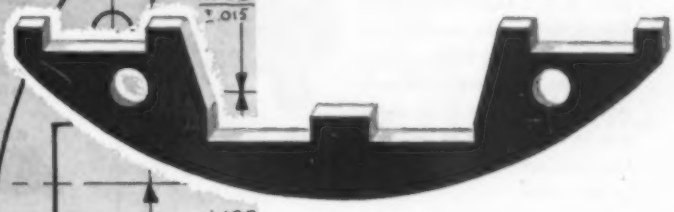
The study is confined largely to the organization of manufacturing companies, with some reference to retail and service activities. The main body of the report is divided into two parts: Part I deals with the dynamics of or-

(Continued on page 417)

Channel valve assembly with carbon guides. Courtesy: Ingersoll-Rand Company, New York.

Channel valves like this have superior quality built in with carbon guides





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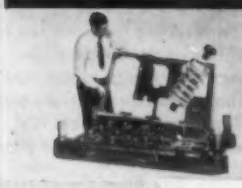

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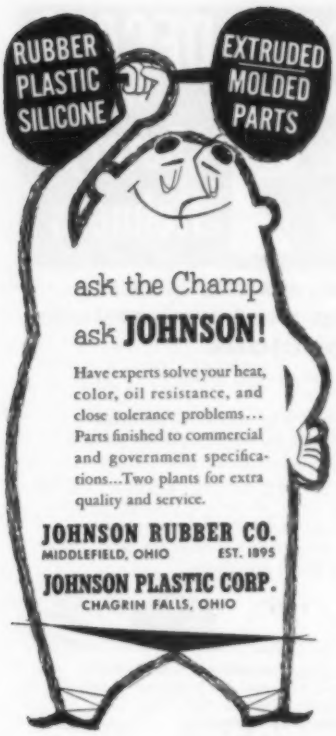

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ganization. This is an analysis of the major organizational problems as they arise at various stages of a company's growth. Part II deals with the mechanics of organization. It offers detailed guidance for analyzing the existing structure and modifying or changing it, in the light of the best established practices, to conform to the needs of the individual company.

NEL Reliability Bibliography

Compiled by W. E. JORGENSEN, I. G. CARLSON, *and* C. G. GROS, *of NEL Library.* 11¾ x 8¾ *in.*, 113 *pp. Available from the Commanding Officer and Director, U. S. Navy Electronics Laboratory, San Diego 52, California.*

For the past several years there has been a widespread interest in the subject of reliability of electronics equipment. As one part of the program to emphasize reliability, the U. S. Navy Electronics Laboratory has prepared and distributed several publications on the subject. Principal ones are: NEL Reliability Design Handbook, Suggestions for Designers of Electronics Equipment, and now the NEL Reliability Bibliography. The bibliography, like the handbook, will be kept up to date with periodic supplements.

The NEL Reliability Bibliography is compiled in accordance with suggestions from the Advisory Group on Reliability of Electronics Equipment (AGREE) which operates under the Office of the Assistant Secretary of Defense (Applications Engineering) and includes representatives from the Dept. of Defense and Industry. The publications referenced in the bibliography include material published since 1950 and are listed under the appropriate subject heading from the following list suggested by AGREE:

1. Circuit design
2. Components
3. Electron tubes
4. Failure analysis
5. General
6. Human engineering
7. Maintenance
8. Mechanical design
9. Systems
10. Testing

Most of the publications listed in the bibliography are available from technical libraries. Some of the more

(Continued on page 419)

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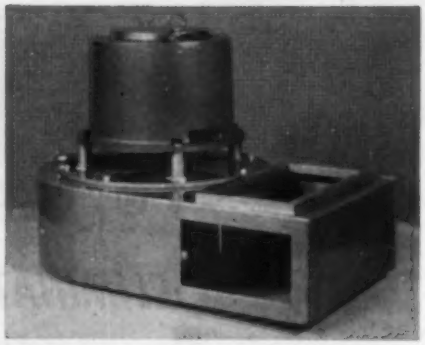

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specialized publications such as technical reports may be available from the issuing agency listed in the reference or from the Armed Services Technical Information Agency, Knott Building, Dayton 2, Ohio.

References in the bibliography are listed by title of the article, followed by the author or authors, the publication in which the reference appears, and the date. A brief abstract is included.

These three publications are available to Dept. of Defense activities and to a limited extent to government contractors upon request to the Commanding Officer and Director, U. S. Navy Electronics Laboratory, San Diego 52, California.

Engineering Mechanics Fourth Edition

S. TIMOSHENKO, *Professor, and* D. H. YOUNG, *Professor; Stanford University.* 6 x 9 in., 530 pp. *Published by McGraw-Hill Book Co.*, 330 W. 42 St., New York 36, N. Y. $7.50.

The practical engineer is continually being confronted by new problems, which do not always yield to routine methods of solution. To successfully cope with such problems, the engineer must have sound understanding of the fundamental principles that apply and be familiar with various methods of attack rather than proficient in the use of only one. This book seeks to build such a foundation with one of the most fundamental subjects in engineering—that of engineering mechanics.

Special attention is given to the selection and treatment of illustrative examples. The solution of a problem in mechanics usually consists of three steps: (1) Reduction of a complex physical problem to such a state of idealization that it can be expressed algebraically or geometrically; (2) solution of this purely mathematical problem; and (3) interpretation of the results in terms of the given physical problem. Too often the reader's attention is called only to the second step so that he does not clearly see the connection to the true physical problem. This book emphasizes the successive development of each illustrative example.

The contents are classically divided

(Continued on page 421)

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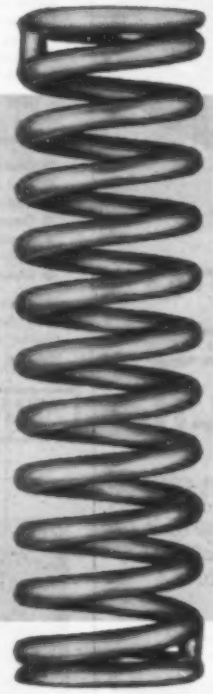

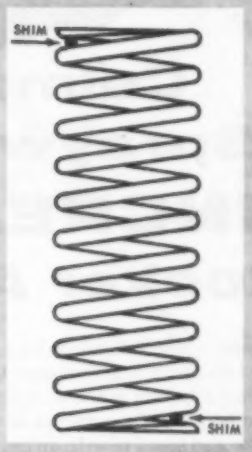

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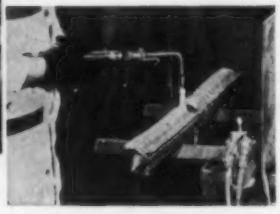
Colmonoy No. 6 hard-facing alloy stopped the excessive metal-to-metal wear between the rocker arms shown and the cast iron cam shafts that operate them. Wear resistant Colmonoy No. 6 is sprayed on with the Colmonoy Spraywelder and fused in with an oxy-acetylene torch.

Rocker arms being sprayed with the Spraywelder.



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into two major categories: statics and dynamics. The section on statics includes a chapter on the principle of virtual work which acquaints the reader with a method that can be used to greatly simplify many principles in statics. In the section dealing with dynamics, equations of motion are presented and handled as differential equations. This makes it possible to properly emphasize the inherent difference between dynamic problems involving known motion and those involving acting forces.

New Report for Businessmen

Consultant Reports, a new business service, is being inaugurated by the Mc-Graw Hill Book Co. It is designed to get practical, comprehensive information to businessmen before the time for decision-making is past. According to a statement by *Business Week* senior editor, Merlyn S. Pitzele, "This service is shaped to meet one of the most pressing needs of management today—the need for competent, experienced and specialized management counsel where profits are at stake." *Consultant Reports* reflect the experience of various specialists in different areas of management.

The first report, "Make or Buy," examines a question facing many businessmen today: how far upstream should a company integrate? The next report, dealing with new money for financing company growth, is the work of George J. Leness, Gillette K. Martin, and Roger T. Gilmartin, of the firm of Merrill, Lynch, Pierce, Fenner and Beane. Determining price policies is the subject of a third by A. J. Bergfeld, a senior partner of Stevenson, Jordan and Harrison, Inc. Leonard Silk, staff economist of *Business Week*, and M. Louise Curley, economist of Scudder, Stevens and Clark are the authors of a report dealing with contemporary techniques of business forecasting.

The publication will be issued at intervals during the year, available both individually at $15.00 and on a subscription plan at $12.50 each. Further information may be obtained from *Consultant Reports*, McGraw-Hill Book Co., 327 W. 41 St., New York 36, N. Y.

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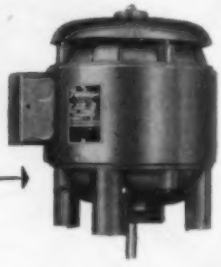
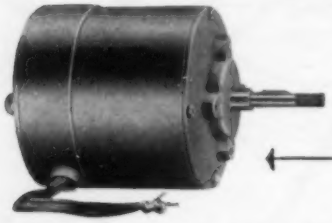


NAVY MOTOR SPRAY-TIGHT



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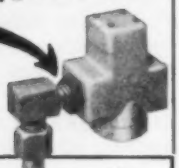

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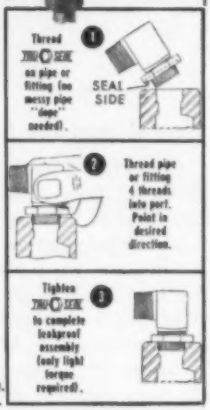
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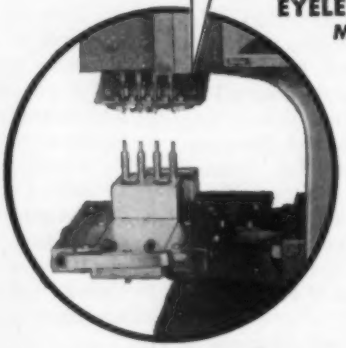

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OUR READERS SAY . . . . . .

Letters should be addressed to the Editor, *Product Engineering*, 330 W. 42 St., New York 36, N. Y.

Symbolic not Simplified

To the Editor:

I was unpleasantly surprised when I saw the illustration which you used to preface the articles by Dean J. Gerardi and Jay H. Bergen in the July, 1956, issue of *Product Engineering*. I feel that the illegible and unintelligible drawings were an unfortunate choice. It has given the impression that a simplified drawing is an unreadable drawing which can cause only confusion to the user.

Since your footnote to the Gerardi-Bergen articles invites comments on the subject, I would like to take this opportunity to discuss one point which has been mentioned frequently and is again touched upon by Mr. Gerardi in the last paragraph of his article—why the movement toward simplification of industrial drawings was not based on sound standardization of practice.

At the very outset of our program to streamline drafting practices, we in General Electric realized the importance of promoting sound standards on a national basis. We endeavored to obtain the support of various standardizing bodies with the hope of integrating into the new ASA-Y14 standard, and others then in the formative stages, at least some of the elementary practices. W. L. Healy, who is on the editing committee of ASA-Y14 and the writer, who is chairman of ASA-Y14 Committee I, and several other General Electric individuals, spent considerable time and effort to enlist support of ASA-Y14, SAE, the British and Canadian Standardizing groups and more recently the Dept. of Defense.

With the exception of the British and Canadian groups, our proposals until recently received little or no recognition. Last April significant progress toward standardization of

(Continued on page 425)

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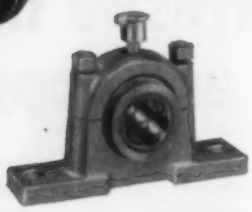

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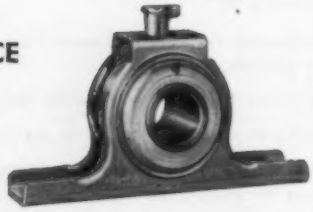

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simplified drafting practices was made when the first meeting of a committee formed to work on the subject by the ASME was held. The Navy's Bureau of Ships and SAE are also now moving towards some form of standardization.

In recent articles on the subject several educators appeared to be unduly disturbed because simplified drafting practices deviate from ASA standards. Apparently they fail to recognize that the introduction of any modern concepts must necessarily represent a departure from the existing standards. If the standards were perpetually followed no major progress would be reflected. It should be expected that any accepted standard can be improved upon or even made obsolete by the introduction of new and progressively more appropriate standards.

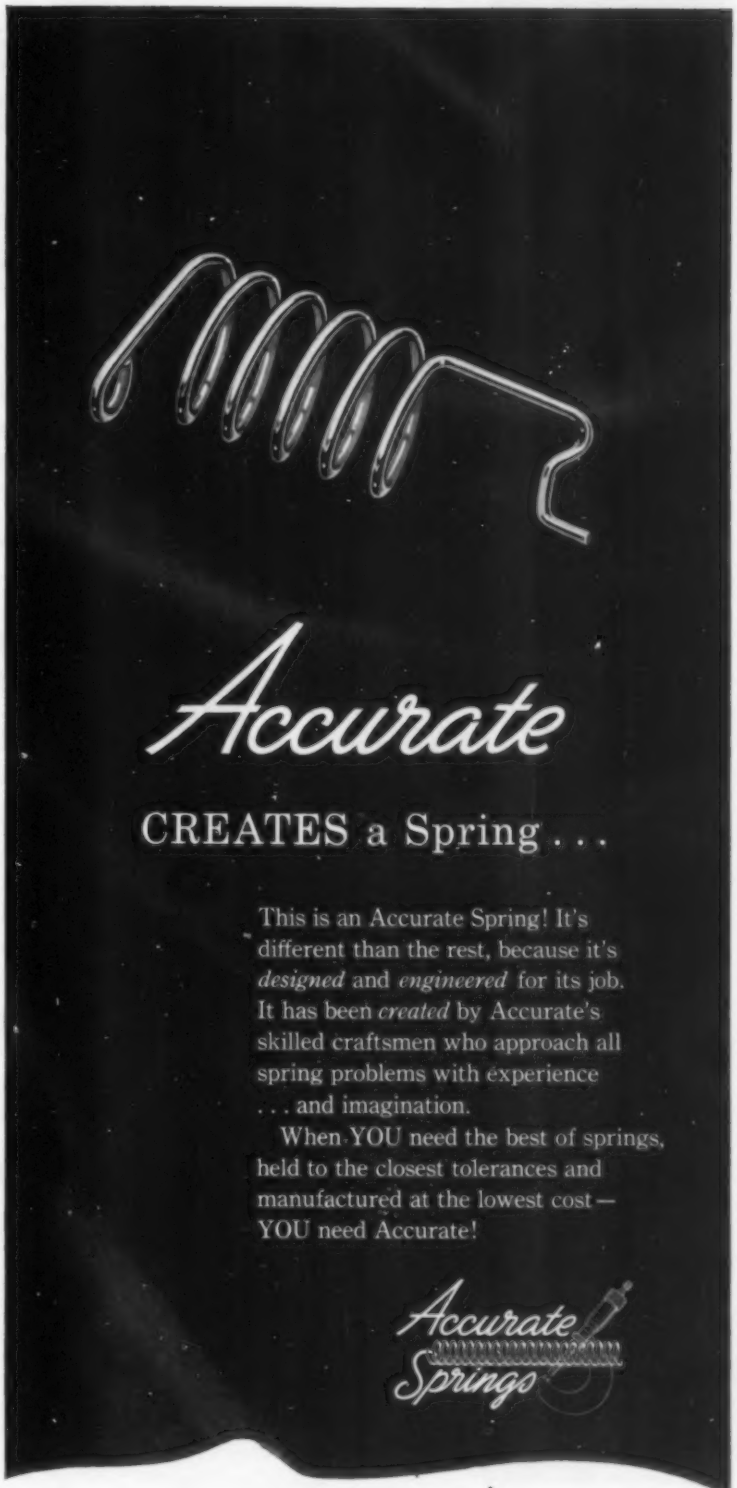
In this instance, expanding business needs, coupled with a critical shortage of competent drafting personnel, warrants a change in the conventional standard. The standard no longer meets the need for which it was originally intended, and, therefore, must be revised. This is not to infer that the standard is inadequate, but rather that changing times and conditions require a reappraisal of it. Whether this should be accomplished by drastic or more subtle means is a matter of opinion and expediency. In General Electric, we believed that expediency, predicated by changing conditions and times, warranted prompt consideration and feel that other manufacturers are faced with the same problem.

Realizing that schools should be cognizant of these needs, several proponents of simplified drafting practices have, for the past three years, participated in American Society for Engineering Education activities in an endeavor to enlist its interest and support in a program to effect appropriate action.

It is very disappointing to find that apparently ASEE is taking very little initiative or part in the program to modernize textbook practices which are based on certain standards long since obsolete.

In closing, on behalf of W. L. Healy, who authored the book, "Simplified Drafting Practice," together

(Continued on page 427)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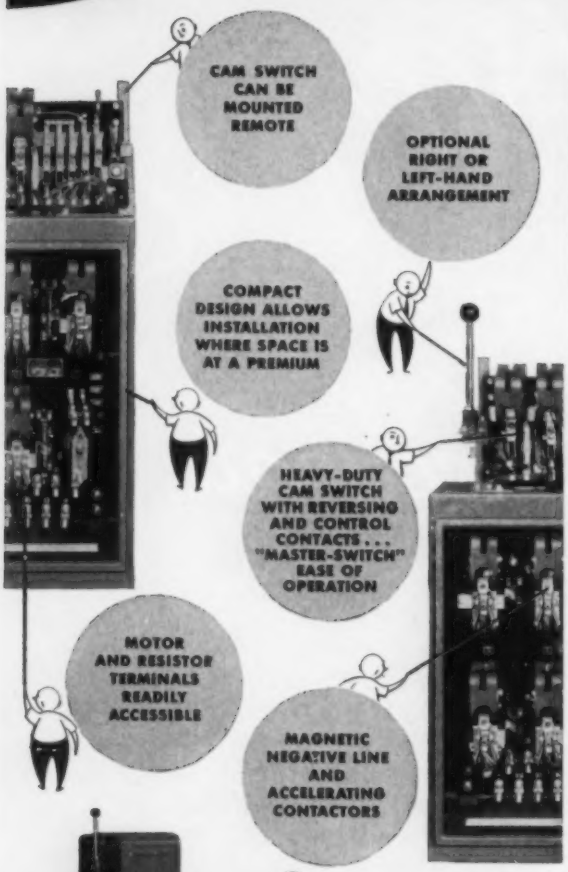
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with myself, I would like to express our appreciation for the time and space which you have devoted to discussions on the subject. We have both found the various articles and comments exceedingly stimulating.

—A. H. Rau
Schenectady, N. Y.

Ed–Much of the job of editing is, "You will be damned if you do and damned if you don't." When the editors schemed up the illustrations for the pro-and-con article they feared that if they put in genuine simplified drawings they would stop the reader and start his mind thinking only of pros and cons. So they decided to make the drawings symbolic. Hence the unreadability of the notations and the completely meaningless sketches. It did not occur to us that those who are strong proponents of simplified drafting would take it amiss because the sketches were not genuine but were what they were meant to be, purely symbolic. We understand why you object and feel that your objection is warranted.

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To the Editor:

We were certainly pleased that you considered the development of bearings faced with fabric of Teflon tetrafluoroethylene fiber of sufficient importance to justify the happy treatment it received in your July issue. In the face of your very favorable story, I feel diffident about calling your attention to the matter of a trademark. However, Teflon is Du Pont's trademark for its tetrafluoroethylene fiber and resin, and we have no choice but to request that it receive the protection which I am sure your magazine extends to registered trademarks.

—Herbert C. Freeman Jr.
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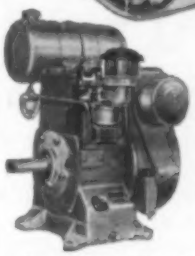

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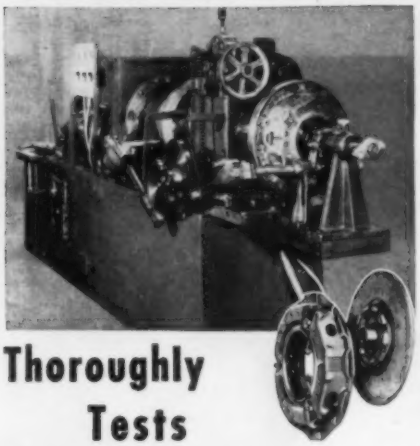

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PRESS PREVIEWS

New Research Laboratory for Union Carbide

New research laboratories in Parma, Ohio, have been constructed by the National Carbon Co., a division of Union Carbide and Carbon Co. The laboratories contain 175,000 sq ft of floor space. The main laboratory building consists of 158 laboratory modules, or individual research units, fully equipped with all the usual service lines and, in addition, unusual features such as lines distributing rare gases. Supplementing the laboratory facilities are adjacent wings housing the chemical engineering and laboratory furnace areas, machine shop, dispensary, a library with a 12,500 volume capacity, cafeteria, locker and shower rooms, boiler and compressor room, and administrative, clerical and business offices.

Designed primarily for basic research in chemical and solid state physics, the multi-million dollar laboratory brings to seven the number of major research centers operated by divisions of Union Carbide and Carbon Co. Under study at the Parma plant will be the fuel cell, a battery that produces electricity from such gases as hydrogen and oxygen. The cell consists of layers of porous carbon and a liquid-paste caustic solution with a space between. Oxygen gas enters the porous carbon and forms a film on the caustic layer producing negatively charged particles. This is the electron-consuming or "positive" section of the battery. The other section, the electron-supplying or "negative" unit, is constructed in a similar fashion but uses of a stream of hydrogen which produces positively charged particles. When developed, fuel cells could be used commercially for reserve or standby power supplies.

Expansion in Magnesium

Brooks and Perkins, Inc. announced plans to build a $7,000,000 plant in Selma, Ala., for the production of

(Continued on page 431)

ARWOOD Investment Casting may be the answer to your design problems when ferrous or non-ferrous parts or components must be of intricate shape and unusual contour, of metals difficult or impossible to machine.

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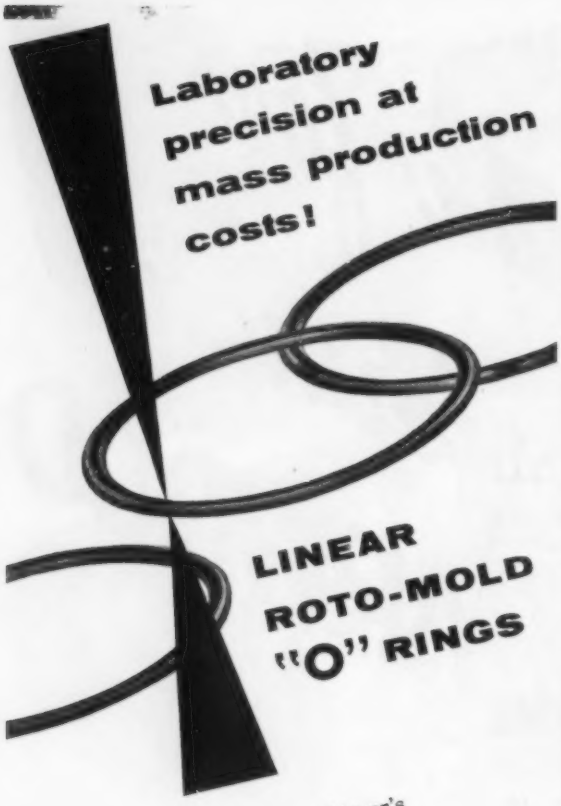

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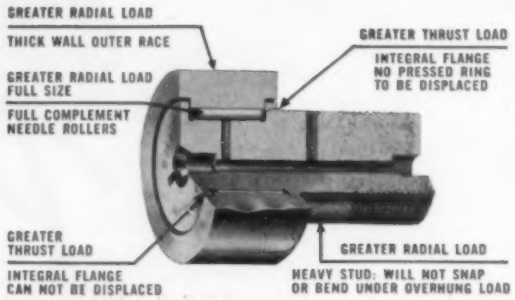
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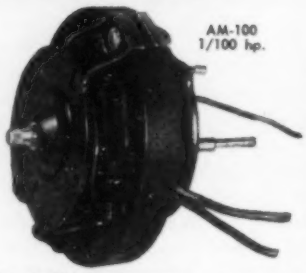

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magnesium. Brooks and Perkins and Dominion Magnesium, Ltd., of Toronto, will be in joint ownership of the new high purity magnesium corporation—the Alabama Metallurgical Corp.

The Dow Chemical Co. announced an expansion of its finishing and cathodic protection technical services for users of magnesium. Under the program, four research personnel of the Dow Metallurgical Lab. will be transferred to the company's Magnesium Technical Service & Development group and will devote full time to the finishing projects of individual customers. Another research engineer will join the Cathodic Protection Sales group to assist customers in projects utilizing magnesium anodes.

Cobalt Information Center

A Cobalt Information Center has been established at Battelle Institute, Columbus, Ohio. Its purpose is to encourage cobalt research and to provide technical and economic information for users in the metallurgical, chemical, ceramics, electronics, pharmaceutical, and nucleonics industries. Data on technological advances will be gathered and organized at the Center, which is being supported by major cobalt producers. The data will then be disseminated to persons and industries desiring cobalt information.

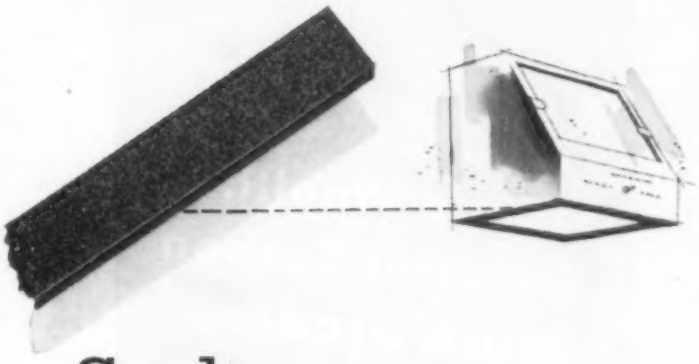
Particle Accelerator To Be Built

A ten-million volt particle accelerator will be developed and constructed by the High Voltage Engineering Corp., Cambridge, Mass., for installation at Chalk River, Ontario, in 1958. Called a "tandem accelerator" it will consist of two specially designed Van de Graaf generators placed end-to-end in a horizontal position, giving the accelerator an over-all length of 34 ft and a diameter of 8 ft. The 35 ton unit will be mounted on a rail in an L-shaped building, 150 ft long and 60 ft wide.

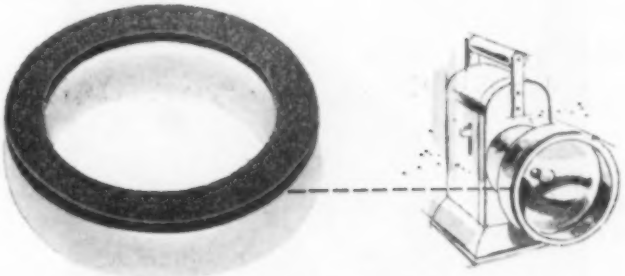
The beam of high speed particles produced will be focussed and deflected in a series of electromagnets into an experimental area 25 ft from

(Continued on page 433)

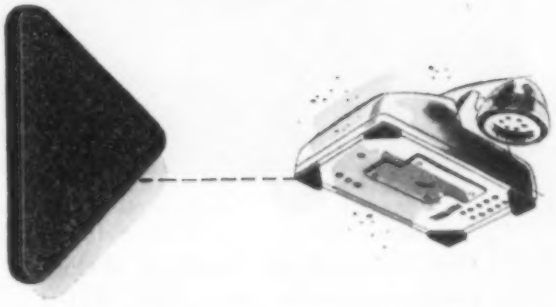
Prevents scratches



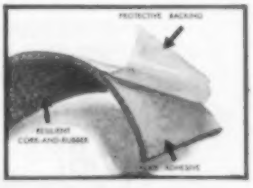
Seals



Skidproofs



Armstrong DK-153 is a resilient cork-and-sponged-rubber composition backed with pressure-sensitive adhesive. This versatile material is now being used for hundreds of different industrial jobs. For example, DK-153 keeps equipment from scratching table tops, keeps moisture and dirt out of electric lanterns, and keeps telephones from slipping on polished desks. You can get DK-153 in rolls, strips, sheets, or die-cut shapes in thicknesses from 1/32″ to 3/16″. In any form, DK-153 is easy to apply: just peel off protective covering and press material into place. For samples, write Armstrong Cork Co., Industrial Div., 7310 Irvin St., Lancaster, Pa.



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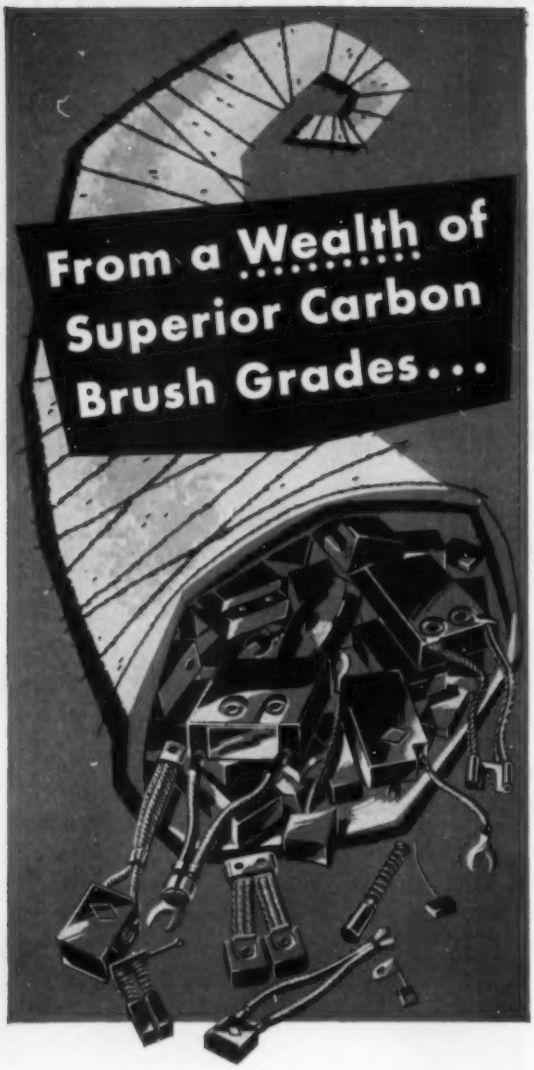

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This book is geared for the beginner as well as for the practicing designer who wants to make better design decisions. Outlines in detail the scheming or "pencil-thinking" stage of the design process; appraises the relative importance of nearly a score of design factors; shows you how to size up the competitive situation and goes into the important subject of manufacturing processes. **By Joseph Shigley, Clemson College, 523 pp., 337 illus., $7.75**

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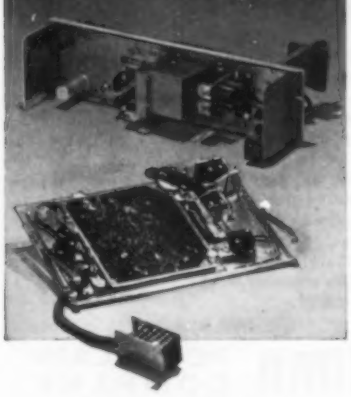

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the accelerator. The machine will be equipped with a switching magnet that will make it possible to shift the particle beam into any one of five directions. The accelerator will incorporate a method of charge exchange whereby the nuclear particle is charged during acceleration permitting the five-million volt potential to impart energy equivalent to a ten-million volt beam.

Gulton Industries Expands Research

The acquisition of an additional building that will eventually add over 50,000 sq ft of research, engineering, and testing space to present facilities, has been announced by Gulton Industries, Metuchen, N. J. Additional building will allow the establishment of a new medical instruments research laboratory and expansion of present ultrasonic research and production for the Vibro-Ceramics Corp. as well as expansion of shock and vibration testing facilities for the Gulton Manufacturing Corp.

Aerojet-General Corp. Plans Engineering Building

Aerojet-General Corp., of Azuza, Calif., announced plans for the immediate construction of a $900,000 engineering building at Azuza. The building is expected to be ready for occupancy by January 1957. The new structure, which will be of steel frame construction, will be two stories in height and have ground measurements of 200 x 300 ft. It will provide office and working space for between 800 and 1000 employees. The company is building the second-stage rocket engine for Project Vanguard, the earth satellite program.

New Plant to Build the Atlas, (ICBM)

The Atlas intercontinental ballistic missile will be built at a new Montgomery Field plant to be known as Convair-Astronautics. The $40,000,000 facility will be devoted to research, development, manufacturing and preliminary testing. Construction of the plant northeast of San Diego

(Continued on page 435)

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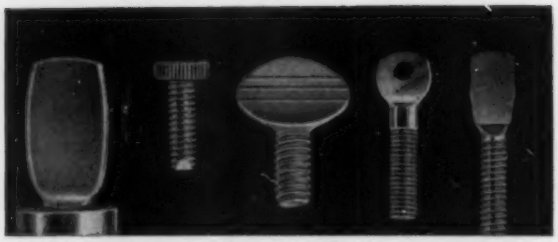
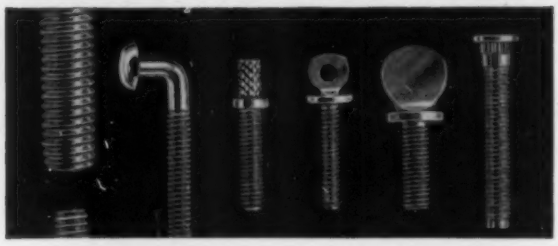
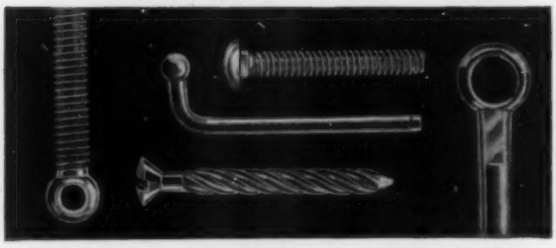


YOU CAN'T BEAT COLD FORMING



FOR PARTS LIKE THESE—AND



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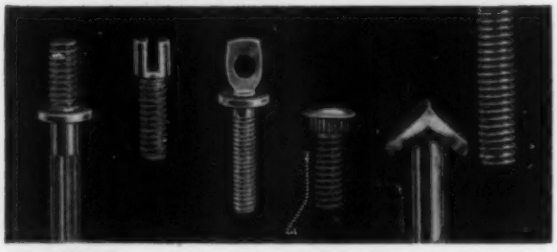
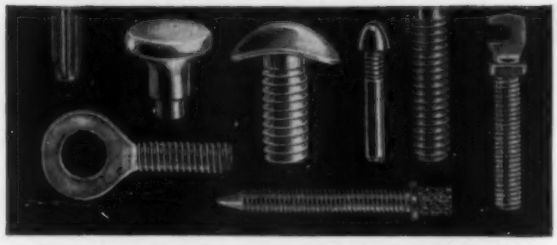


FOR COLD FORMING . . .



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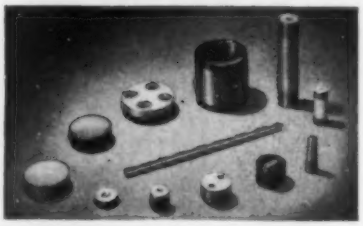

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will get under way this summer and is scheduled for completion in 1957. The plant will have 2 million sq ft of floor space.

It will consist of a one-story high-bay factory building of approximately 500,000 sq ft; two six-story office buildings, each having almost 107,000 sq ft of working area; a 147,000 sq ft engineering laboratory; a cafeteria-auditorium; a 75,000 sq ft instrument and computer center, and several special-purpose test and utility buildings.

New West Coast Perforating Plant

The Diamond Mfg. Co., of Wyoming, Pa., producers of perforated metals, has established a new affiliate in Gardena, Calif. The new firm, Diamond Perforated Metals Co., claims to have the only major perforating plant for complete commercial production on the West Coast. The plant includes the only fully automatic, electronically controlled press, of this type in the country. The new affiliate expects to supply customers in eleven western states.

Expanded Facilities for Electrical Relays

Potter & Brumfield, Inc., manufacturers of relays for the electrical and electronic industries, has completed plans to expand production facilities to more than 125,000 sq ft at their Princeton, Ind., plant. The company, a subsidiary of American Machine & Foundry Co., has already completed construction of a 16,000 sq ft building addition in Princeton. Production operations are now being moved into the new building in Princeton which will serve as an annex to the main plant.

Pilot Plant for Multiwave

Expanded facilities for the pilot plant production of Multiwave, a recently-developed flexible sandwich core material, will be in operation by November at Narmco Metlbond Co. Addition of the new production facilities is the first step in a long-term program aimed at expanding substan-

(Continued on page 437)

Designers

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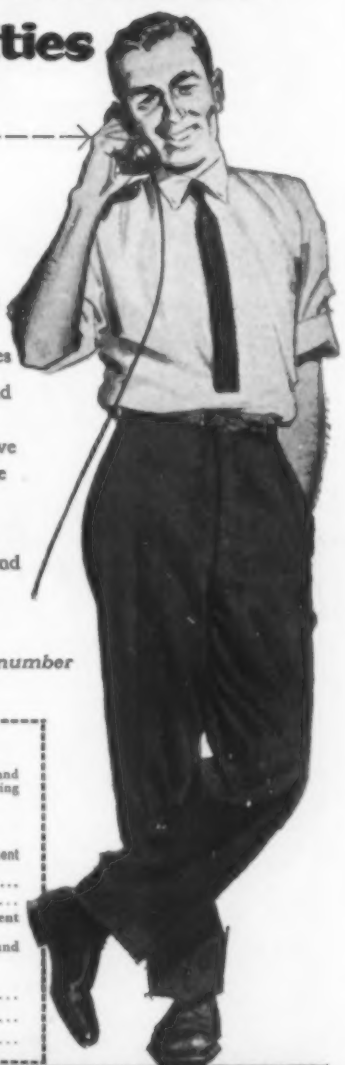
may introduce you to

unusual advancement opportunities



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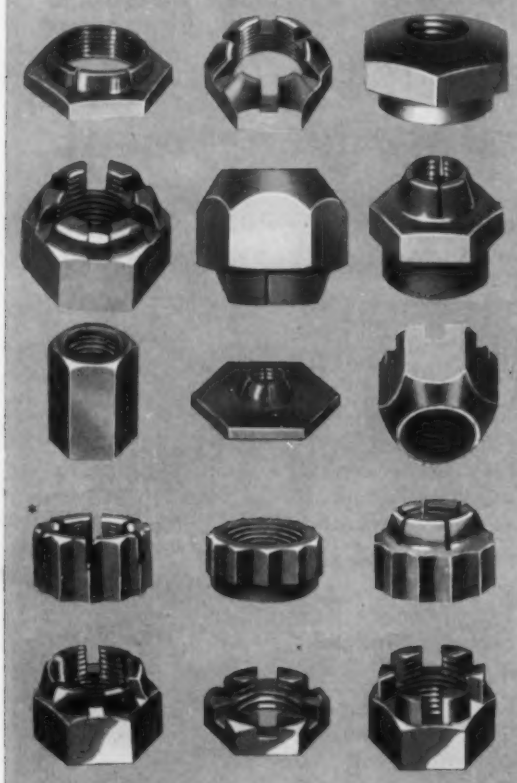

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*Also 12 Pointer brochure on request.

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44251 Utica Rd., UTICA, Michigan

Light Metals Design Tips

MACHINABILITY OF METALS
(Horsepower Per Cubic Inch of Metal Removed Per Minute)

Material	Drilling	Milling	Planing
Magnesium Alloy	0.20	0.28	0.13
Aluminum Alloy	0.31	0.40	0.27
Red Brass	0.40	0.44	0.30
Cast Iron (Hard)	0.52	0.70	0.52
Malleable Iron	0.60	1.01	0.60
SAE 1020 Forged	1.18	1.25	0.88
Tool Steel (1.03% Carbon)	1.4	1.7	1.2
Nickel	2.3	1.9	1.6
Monel	1.5	1.8	1.7

From "Metal Processing," O. W. Boston, Publisher John Wiley and Sons, Inc., New York.

AS THIS TABLE SHOWS . . . Magnesium, of all common structural metals, is easiest to machine, particularly at extremely high speeds. Magnesium normally requires only one-half the power necessary to cut aluminum or brass, one-third the power needed to cut cast iron, one-sixth the power required to cut mild steel and one-tenth the power to cut nickel. The fact that magnesium is a free machining metal in wrought as well as cast form is still another important factor in product design considerations.

Other advantages of magnesium's machinability are (1) an excellent surface finish can be achieved without grinding or polishing, (2) heavier depths of cut and higher rates of feed are possible, (3) standard cutting tools can be used satisfactorily.

Whatever your light metals problem . . . you can count on Magcoa for engineering counsel and fabrication facilities. Write today for a free copy of our Magnesium Design Handbook.

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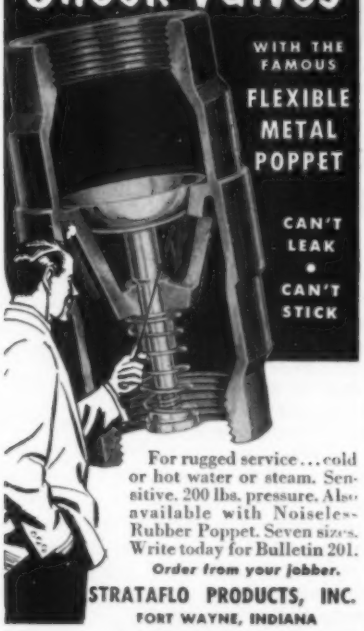

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tially the output of the aircraft structural material which is continuously produced on completely automatic fabricating equipment. Multiwave, which has been in pilot plant production for some months was laboratory developed to meet need for flexible core materials that would lend themselves to rapid, automatic production, especially in the event of an emergency increase in the production of aircraft sandwich structures.

New Aircraft Parts Plant

Ronson Corp. is expanding its production of aircraft parts with the completion of a new plant in Charlotte, N. C. Operations in the new plant began in August and include the design, manufacture and testing of hydraulic valves and cylinder assemblies for the aircraft and missile industries.

Two Mobile Exhibits

Burndy Engineering Co., Norwalk, Conn., has launched their "Hyliner," a 35 ft converted bus displaying the different types and sizes of Burndy compression connectors. The vehicle has been completely rebuilt and decorated to serve as a display and demonstration unit for the company. Containing its own electric generating plant, air-conditioning and indirect lighting, the unit will tour all 48 states and parts of Canada during its first two-year trip.

Cramer Controls Corp., Centerbrook, Conn., has started a tour of their new traveling timer display coach which will visit major industrial plants throughout the country to promote familiarity with timing applications, techniques and timing devices. The traveling exhibit will display industrial and military timers, time-delay relays and synchronous timing motors. The timers are designed to control starting, stopping, and "on-off" schedules of electrically operated equipment.

Motion Pictures Available

Unless otherwise noted, all films listed are 16 mm, color and sound.

"Optical Tooling in Industry"—35 min. Animated drawings and working

(Continued on page 439)

Now on the shelf!

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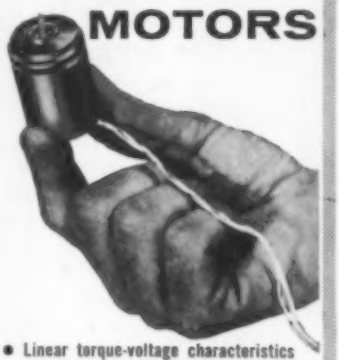

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½	400	115	180
1½	60	115	180
2½	60	115	115
5	60	115	115
5	400	115	115
5	60	115	250/250
5*	60	115	250/250
5	400	115	250/250
5*	400	115	250/250
10	60	115	115
10	400	115	115
10	60	115	250/250
10	400	115	250/250
10**	400	115	57.5/57.5

*Have double shaft extension (all others are single).
**Designed for mag-amp systems.

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☐ Please send me prices on the servo motors I have circled above.

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DIVISION OF THE
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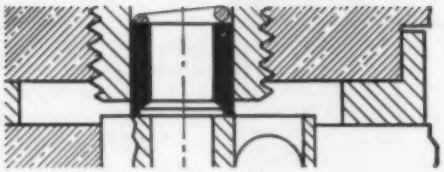

MECHANICAL ENGINEERS

Continually expanding programs at Northrop Aircraft are creating new opportunities for mechanical engineers in the following areas: launching and landing gear design, hydraulics and pneumatics, control systems, and equipment.

You'll enjoy the fine spirit of cooperation at Northrop. The new multi-million-dollar engineering and science center, now nearing completion, will be a great place to work in, both as to its modern architectural design and newest scientific installations. You'll be associated with a top engineering team on such notable projects as Northrop's new supersonic trainer airplane, Snark SM-62 intercontinental missile, and other advanced aircraft and missile programs.

You'll be given constantly fresh, challenging assignments. Remuneration will be substantial, with many benefits that are unexcelled in the entire industry—health and life insurance, college educational reimbursement plan, regular vacations plus extra year-end vacations with pay, and a generous retirement plan.

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You will find the career opportunity you are seeking at Northrop, pioneer in the design and production of all weather and pilotless aircraft. If you qualify for one of these attractive positions, contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600P, Hawthorne, California.

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NORTHROP AIRCRAFT, INC., HAWTHORNE, CALIFORNIA
Producers of Scorpion F-89 Interceptors and Snark SM-62 Intercontinental Missiles

models of optical instruments present a method of measuring, positioning and aligning. Loaned free by Charles Bruning Co., 4700 Montrose Ave., Chicago 41, Ill.

"Transflex–Automation in Action"—22 min. This film describes the construction of the feed mechanisms, the operation of the press line and the significance of a new press design. Loaned free by Clearing Machine Corp., c/o U. S. Industries Inc., 6201 West 63rd St., Chicago 38, Ill.

"Positioning Equipment"—35 mm sound slide film, 18 min. This film discusses welding positioners, automatic manipulators and turning rolls. Obtainable through Worthington Corp., Harrison, N. J.

"Magnetic Multi-Frequency Test Film"—This film covers a frequency range from 50 through 7000 cps and provides a reference standard for measuring and adjusting the electrical characteristics of magnetic sound systems. Available from SMPTE, 55 West 42nd St., New York 36, N. Y.

New Divisions

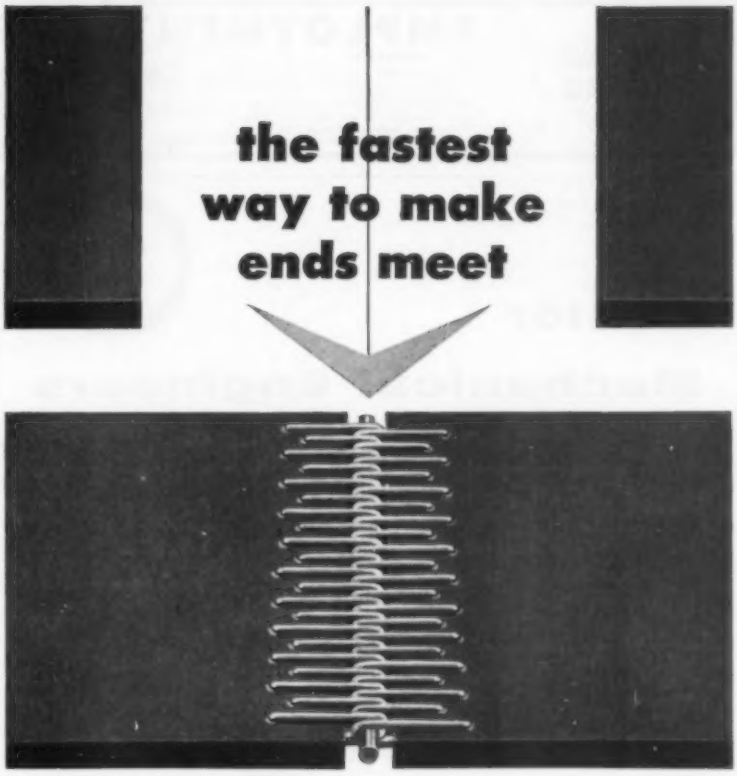
Clark Controller Co., Cleveland, Ohio, has established a Los Angeles office headed by King D. Christophers. The new division will include engineering and manufacturing departments.

Burroughs Corp., Detroit, Mich., have formed a new Electronic Tube Div., in Plainfield, N. J. The new divison managed by Saul Kuchinsky will be responsible for the manufacture and sale of special vacuum tubes.

Dow Chemical Co., Midland, Mich., have formed a new Textile Fibers Dept. The new division will be managed by Arthur E. Young.

Lockheed Missiles, Van Nuys, Calif., have appointed Harry W. Kohl, as division engineer for the newly created Bay area division.

Superior Tube Co., Norristown, Pa., have created an Aperture Mask Dept. at their plant No. 3 in Phoenixville, Pa. These masks will be used by color television tube manufacturers.



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in materials handling, food harvesting and processing, power transmission, wherever flat ends must be joined.

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- *produces secure, flexible joints in minutes*
- *does not injure belting*
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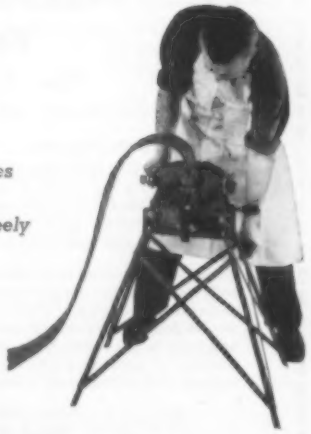

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Send a sample of your belting, apron or ribbon to Clipper with an outline of your problem. They'll determine the best method of fastening and then lace your sample FREE.

Ask your Industrial Distributor for Clipper Products

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Pacific Semiconductors has openings for Senior Mechanical Engineers for the design and development of automatic and semi-automatic machinery and equipment for manufacturing semiconductor devices including diodes and transistors of advanced design. B.S. or M.S. degree in mechanical engineering, five or more years experience, and ability to carry project responsibility is required. Salary will be commensurate with ability, training and development potential of the applicant.

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State salary requirements
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2. Recognition by others?
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A Supervising Methods Engineer with a full background in heavy manufacturing and fabrication.

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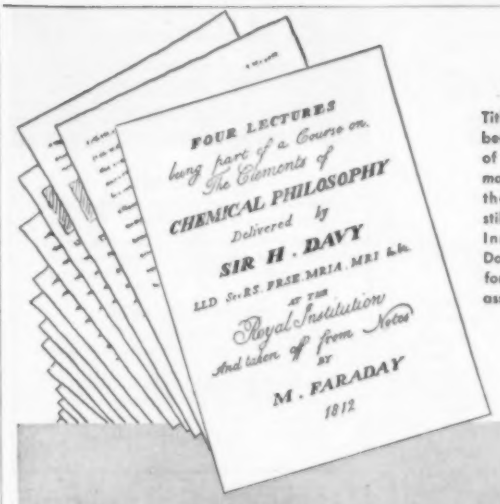

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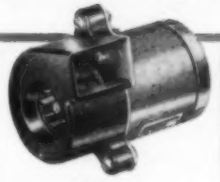

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LINE TYPE (cutaway)

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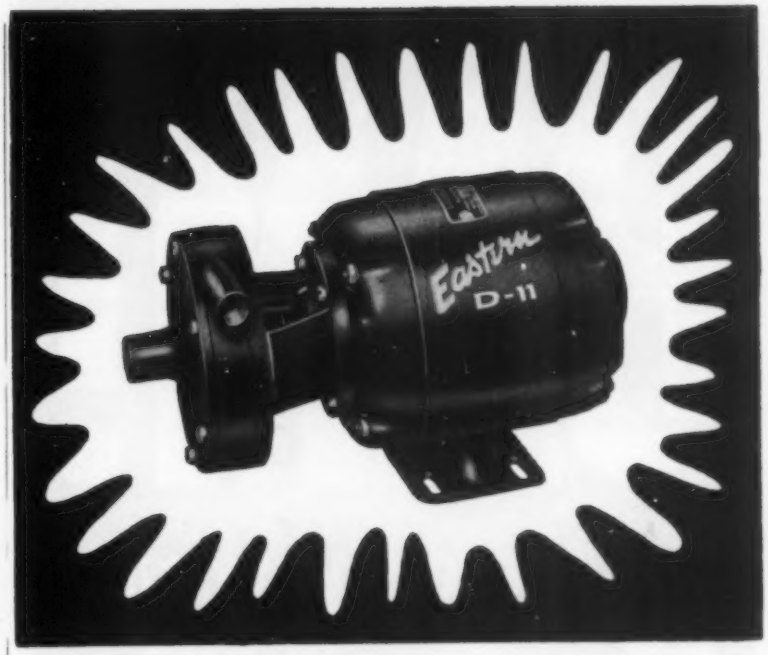

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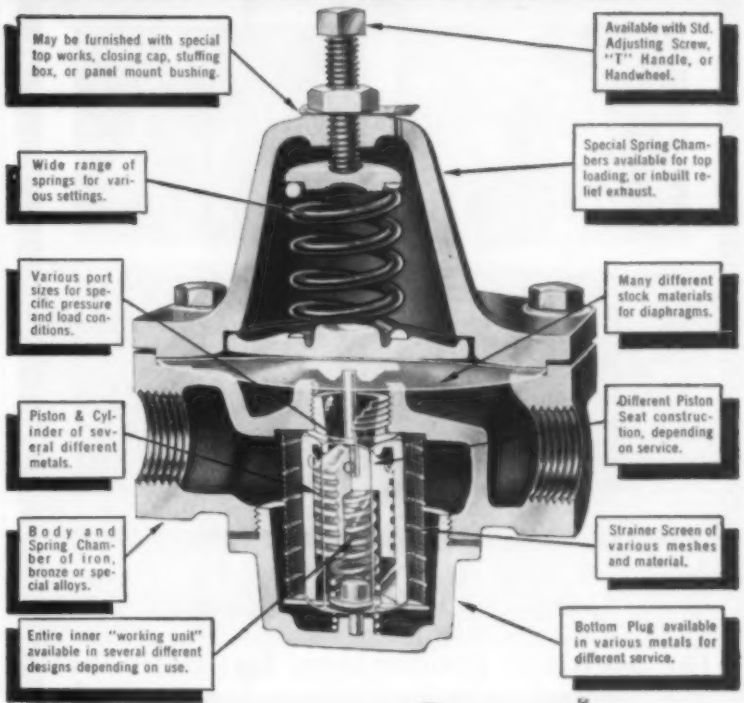
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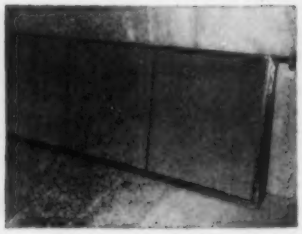
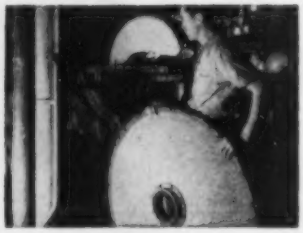

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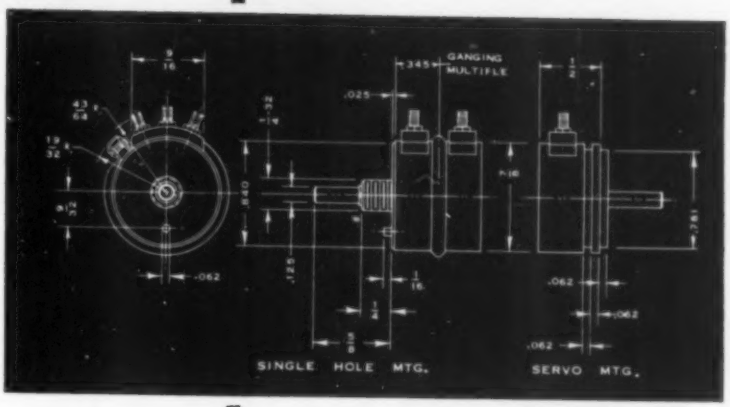

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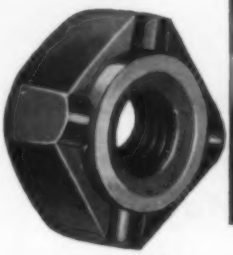

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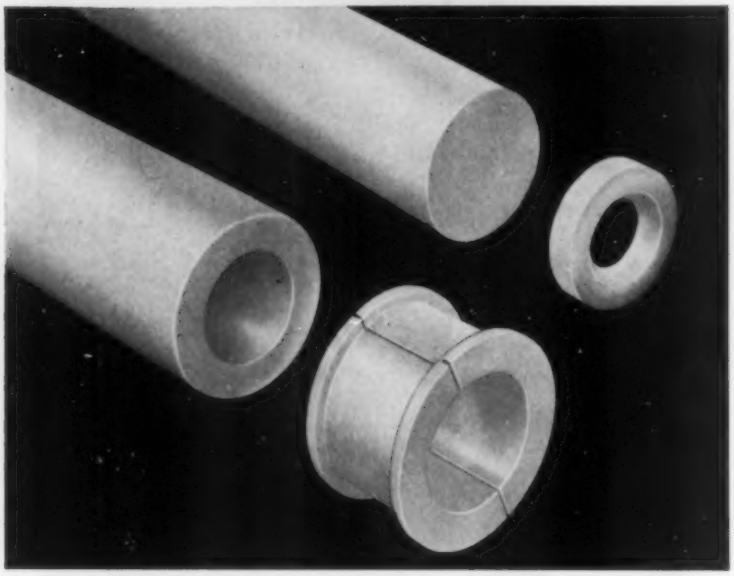

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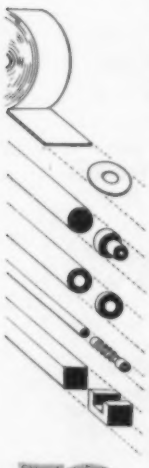

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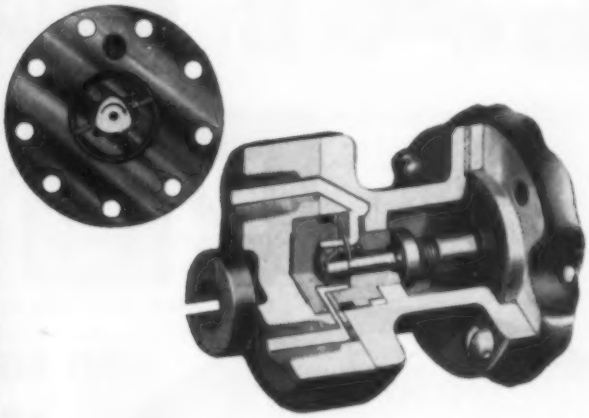

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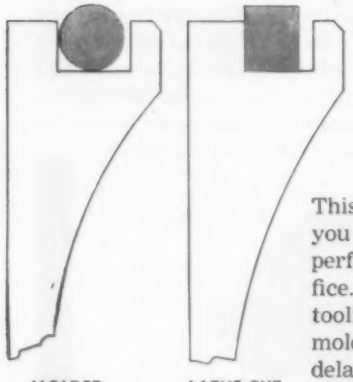

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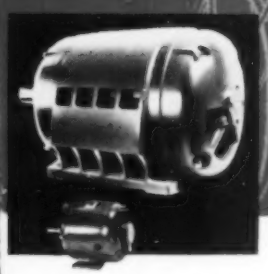

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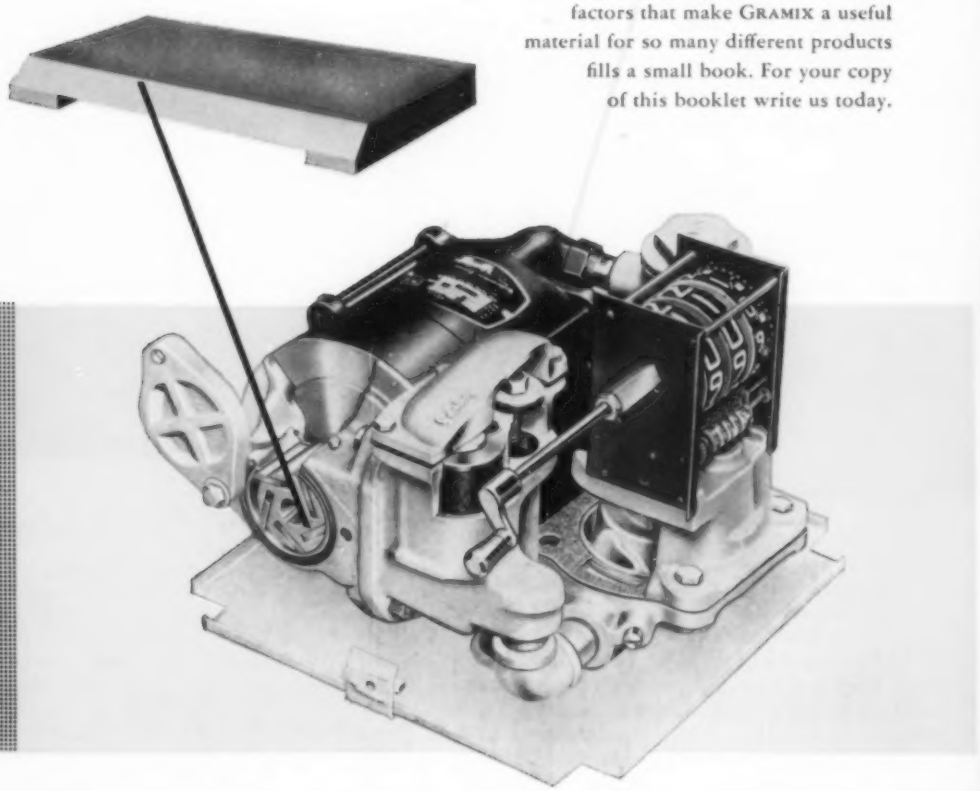

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